

Welcome Aboard.

NASA/AMES Research Center operates and maintains the C-141 AIRO as an important and vital service to the scientific community. We sincerely hope the data contained in this handbook has been helpful and beneficial to you, the C-141 AIRO Investigator. We welcome your comments and suggestions for inclusion in future revisions of the handbook.

Good luck in your up-coming missions on the C-141 Airborne Infrared Observatory.

NASA C-141 AIRBORNE INFRARED OBSERVATORY

INVESTIGATOR'S HANDBOOK

INTRODUCTION

The NASA C-141 Airborne Infrared Observatory (AIRO) is a National Facility dedicated to research in astronomy. The observing platform is a modified four-engine jet transport with a range of about 9700 km and a current operational ceiling of 14 km.

The telescope, a conventional Cassegrain of 91.5-cm clear aperture, is designed primarily for observation in the 1 to 2,000 μm spectral region. It views athwartship from an open cavity recessed ahead of the wing in the left side of the fuselage.

The observatory is based at Ames Research Center, Moffett Field, California and operated for scientists whose proposals are deemed suitable and have been approved by NASA Headquarters.

The purpose of this handbook is to acquaint potential users with the observatory and its capabilities, to describe the established procedures for securing approval of research programs, and to outline the requirements for equipment design and installation. As new modifications and procedural changes occur, revision sheets will be mailed to recipients for insertion in the handbook - hence, the looseleaf format.

It is the intent of the Airborne Science Office that individual scientists and visiting experimental teams find at Ames an environment favorable to the conduct of their scientific research. The handbook helps establish this spirit by presenting realistic guidelines which encourage competent research groups to use the telescope.

Although the AIRO is operated in a manner analogous to ground-based observatories, there are certain restrictions and operational requirements unique to aircraft platforms. It is important for users to design, stress-analyze, and construct their equipment in accordance with accepted aircraft standards. The reader's attention is called particularly to Section II of this handbook for detailed data which may affect the design of experimental equipment.

This handbook has been provided to the Airborne Science Office by Walter V. Sterling, Inc.

INVESTIGATOR'S HANDBOOK
C-141 AIRBORNE INFRARED OBSERVATORY

TABLE OF CONTENTS

	<u>PAGE</u>
INTRODUCTION.....	<i>i</i>
TABLE OF CONTENTS.....	<i>ii</i>
LIST OF FIGURES.....	<i>viii</i>
LIST OF TABLES.....	<i>x</i>
SECTION I - AIRBORNE INFRARED OBSERVATORY DESIGN AND PERFORMANCE	
CHARACTERISTICS	
1.0 Overall Design and Performance.....	I - 1
2.0 Optical Performance.....	I - 4
3.0 Telescope Environment Control.....	I - 4
4.0 Telescope Stabilization and Image Acquisition.....	I - 7
5.0 Electrical Power.....	I - 9
6.0 Telescope Support Systems.....	I - 9
6.1 Airborne Data Acquisition & Management System (ADAMS)...	I - 9
6.2 Helium Pumping System.....	I - 10
6.3 Water Vapor Observations.....	I - 10
6.4 Cryogenic Source.....	I - 12
6.5 Environmental Control System.....	I - 12
6.6 Intercommunication System.....	I - 13
6.7 AIRO Simulator.....	I - 14
7.0 On-Board Facilities and Accommodations for Investigators.....	I - 15
7.1 Floor Plan.....	I - 15
7.2 Cabin Environment.....	I - 15

TABLE OF CONTENTS, Continued

PAGE

8.0	In-Flight Standard Operating Procedures.....	I - 17
8.1	Investigator-Aircraft Personnel Interface Guidelines....	I - 17
8.2	Interface with Aircraft Commander.....	I - 17
8.3	Interface with Crew Chief.....	I - 17
8.4	Interface with Support Systems Operating Personnel.....	I - 17
8.5	Alteration in Mission Profile.....	I - 18
8.6	Emergency Procedures.....	I - 18
9.0	Operations and Use of the Telescope by Investigator Personnel.....	I - 18

SECTION II - INVESTIGATOR EQUIPMENT, DESIGN, DEVELOPMENT AND ASSEMBLY

1.0	Coordination and Planning.....	II - 1
1.1	Leadtime.....	II - 2
1.2	Investigator's Program Questionnaire.....	II - 2
1.3	Mission Profile Planning.....	II - 2
2.0	Basic Design Determinants for Investigator Instruments and Flight Support Equipment.....	II - 2
2.1	Environmental Considerations.....	II - 6
2.2	Weight, Dimension and Center of Gravity Constraints.....	II - 8
2.3	Electrical Power Available.....	II - 9
2.4	Airworthiness and Safety Considerations.....	II - 11
3.0	Direct Cassegrain Mounting.....	II - 13

TABLE OF CONTENTS, Continued

PAGE

3.1	Demonstrated Performance at Reduced Atmospheric Pressure.....	II - 14
3.2	Compatibility with Instrument Interfacing Drawing.....	II - 14
3.3	Connection of Instrument to Power, Signal, and Helium Pumping Lines (Direct Cassegrain).....	II - 14
4.0	Bent-Cassegrain Mounting.....	II - 15
4.1	Demonstrated Performance at Reduced Atmospheric Pressure.....	II - 15
4.2	Compatibility with Instrument Interfacing Drawing.....	II - 15
4.3	Connection of Instrument to Power, Signal and Helium Pumping Lines (Bent Cassegrain).....	II - 16
5.0	Rack-Mounted Equipment.....	II - 16
5.1	NASA Equipment Rack.....	II - 16
5.2	Cables, Wire Types, and Sizes.....	II - 17
5.3	Connector Types, Keying, and Pin Assignments.....	II - 17
6.0	Other Investigator On-Board Equipment.....	II - 18
7.0	Equipment Certification for Special Equipment.....	II - 18
7.1	Aircraft Fasteners and Welding.....	II - 19
7.2	High Voltages.....	II - 19
8.0	Construction Guidelines.....	II - 20
8.1	Stripping Insulation.....	II - 20
8.2	Soldering.....	II - 20

TABLE OF CONTENTS, Continued

PAGE

8.3	Electrical Wiring.....	II - 20
8.4	Vibration Considerations.....	II - 21
8.5	Fabrication Check.....	II - 21

SECTION III - TEST, INTEGRATION AND MISSION PREPARATION

1.0	Investigator Equipment Test.....	III - 1
1.1	Static Testing.....	III - 1
1.2	Environmental Testing.....	III - 1
1.3	Support Test Equipment.....	III - 1
1.4	Clean Room.....	III - 2
2.0	System Integration & Testing at NASA/ARC (Ames Simulator)...	III - 2
2.1	General Considerations.....	III - 2
2.2	Mechanical Conformance Check.....	III - 2
2.3	Vibration and Shock.....	III - 3
2.4	Electrical Power Consumption Check.....	III - 3
2.5	Ambient, Static Performance Check.....	III - 3
2.6	Operating Altitude and Temperature.....	III - 3
3.0	Integration and Checkout as Part of the AIRO.....	III - 3
3.1	Instrument Package Installation.....	III - 4
3.2	Equipment Rack Installation.....	III - 4
3.3	Cable Installation and Checkout.....	III - 4
3.4	Installation Inspection.....	III - 5
3.5	EMI/EMC Testing.....	III - 5
3.6	Pre-Flight Test.....	III - 6

TABLE OF CONTENTS, Continued

PAGE

4.0	Test and Integration Review.....	III - 6
5.0	Airworthiness and Safety Review.....	III - 7
6.0	Flight Plan Development.....	III - 7
7.0	Pre-flight Briefing.....	III - 8
8.0	Manifest Preparation.....	III - 8
9.0	Insurance.....	III - 8

SECTION IV - PROPOSAL PROCEDURES

1.0	General Description.....	IV - 1
1.1	Proposal Guidelines and Constraints.....	IV - 1
1.2	Proposal Content.....	IV - 1
1.3	Additional Proposal Information.....	IV - 3
1.4	Proposal Routing.....	IV - 3
1.5	Proposal Acceptance.....	IV - 4

SECTION V - TRANSPORTATION, HANDLING AND STORAGE

1.0	Preparation For Transportation.....	V - 1
1.1	Transportation.....	V - 1
1.2	Handling.....	V - 1
1.3	Storage.....	V - 2

SECTION VI - AIRO INFORMATION BULLETINS

AIRO Information Bulletin #6
AIRO Information Bulletin #7

SECTION VII - REFERENCE DATA

Reference A - C-141 AIRO Project Organization and Management.....	VII-A-1
Reference B - Variations of the Tropopause as a Function of Seasonal Variations and Geographic Location.....	VII-B-1
Reference C - Loading Considerations for the NASA/Ames Double-Bay Equipment Rack for the C-141.....	VII-C-1
Reference D - Recommended Soldering Practices.....	VII-D-1
Reference E - Equipment Performance Characteristics.....	VII-E-1

LIST OF FIGURES

			<u>ON PAGE</u>
			<u>FOLLOWING</u>
FIGURE	I - 1	Airborne Observatory.....	I - 1
	I - 2	Telescope Installation - View Outboard.....	FIG I - 1
	I - 3	Telescope Installation - View Forward.....	FIG I - 2
	I - 4	Focal Plane Monitor.....	I - 2
	I - 5	Tracking Subsystem Block Diagram.....	I - 8
	I - 6	Acquisition Field-Mapping-Mode Scan Pattern...	FIG I - 5
	I - 7	Search-Mode Scan and Video Signal.....	FIG I - 6
	I - 8	Track Scan Pattern.....	FIG I - 6
	I - 9	Extended Target Tracking.....	FIG I - 8
	I - 10	Extended Limb Vs Limb Sampling.....	FIG I - 8
	I - 11	Limb Track Limitations.....	FIG I - 10
	I - 12	Limb Tracking Target Near Poles.....	FIG I - 10
	I - 13	ADAMS Block Diagram.....	I - 9
	I - 14	Investigator's Intercommunication System Station Locations.....	I - 13
	I - 15	Plan View of AIRO.....	I - 15
	I - 16	Cargo Door and Ramp Area.....	I - 18
	I - 17	Location of Safety Equipment.....	FIG I - 16
FIGURE	II - 1	Airborne IR Observatory General Operating Plan.....	II - 2
	II - 2	Investigator's Interface Flange Section Connector Plate and Selector Wheel with Pressure Windows.....	II - 7
	II - 3	Direct-Cassegrain Instrument Package Limits...	II - 3
	II - 4	Instrumentation Package Locations.....	FIG II - 3
	II - 5	Bent-Cassegrain Instrument Package Limits.....	FIG II - 4
	II - 6	Investigator's Standard Double-Bay Rack.....	FIG II - 5

LIST OF FIGURES, Continued

ON PAGE
FOLLOWING

FIGURE	II - 7	Two Standard Racks.....	FIG II - 6
	II - 8	Typical Rack-Mounted Equipment.....	FIG II - 7
	II - 9	Investigator's Equipment Rack Power Distribution Panels.....	II - 10
	II - 10	Base of Telescope.....	II - 14
	II - 11	Direct-Cassegrain Instrument Interface.....	FIG II - 10
	II - 12	Investigator's Cable Routing.....	FIG II - 11
	II - 13	Bent-Cassegrain Flange Section Connector Plate.....	II - 16
	II - 14	Standard Double-Bay Rack Dimensions.....	II - 17
	II - 15	Investigator's Junction Box/Connector Plate Interface.....	FIG II - 14
	II - 16	Investigator's Junction Box.....	FIG II - 15
FIGURE	VII-A-1	C-141 AIRO Project Functional Organization....	VII-A-1
	VII-B-1	Semiannual Mean Tropopause Cross Section Pole to Pole.....	VII-B-2
	VII-C-1	Rack Mounted Equipment Center of Gravity.....	TBL VII-C-1
	VII-C-2	Plan View of Rack.....	FIG VII-C-1
	VII-C-3	Rack Torque Moments.....	FIG VII-C-1
	VII-C-4	Typical Locations of Heavy Chassis Fore and Aft.....	VII-C-3

LIST OF TABLES

			<u>PAGE</u>
TABLE	I - 1	Pressure Wheel Window Characteristics.....	I - 2
	I - 2	Summary of Telescope Design Characteristics...	I - 5
	I - 3	Cabin Pressure Vs Aircraft Altitude.....	I - 16
TABLE	II - 1	Investigator-ASO Interaction.....	II - 1
	II - 2	Investigator's Program Questionnaire.....	II - 3
	II - 3	Mechanical Load Conditions.....	II - 6
	II - 4	Cabin Environment.....	II - 7
	II - 5	Attributes of Electrical Power Sources for Investigator Equipment.....	II - 10
	II - 6	Restricted Frequencies.....	II - 13
TABLE	VII-C-1	Allowable Rack Loading.....	VII-C-3
	VII-E-1	Equipment Performance Characteristics.....	VII-E-2

C-141 AIRBORNE INFRARED OBSERVATORY

INVESTIGATOR'S HANDBOOK

S E C T I O N I

DESIGN AND PERFORMANCE CHARACTERISTICS

The telescope system installed aboard the C-141 is depicted by an artist's drawing in Figure I-1. The telescope views athwartship from an open cavity recessed ahead of the wing in the left side of the fuselage. A hatch section containing an open orifice covers the cavity. This hatch section and the telescope can be moved in flight over the elevation range 35° to 75° above the horizontal plane. The orifice is large enough to preclude vignetting of the telescope over a 4° field of view centered in the orifice. A watertight shutter seals the opening when the telescope is not in use. Porous spoilers are located in front of the orifice to control the flow of air across the opening and minimize pressure fluctuations in the cavity. When the orifice is closed the spoilers are retracted against the fuselage. A full-aperture Schott BK-7 window is available for use during those visible and near-IR observations that can tolerate intervening glass.

The main telescope is a conventional Cassegrain supported by an all-Invar A-frame structure and head ring (Figures I-2, I-3). The frame and head ring, designed for minimum flexure and low thermal expansion, also support the acquisition and tracking telescopes. These telescopes are attached to the forward side of a 41 cm diameter Invar air bearing, the single suspension point for the entire telescope/instrument system. The air bearing and its matching spherical socket are embedded in the aft cavity pressure bulkhead. Instruments which are unusually bulky and/or heavy, or which will require regular attention during flight may be installed at the bent Cassegrain focus by utilizing a flat CER-VIT tertiary mirror between the primary and secondary mirrors to fold the optical axis of the telescope through an aperture in the air bearing and focus at the equipment mounting flange.

The primary mirror is a solid CER-VIT paraboloid with a 183 cm focal length ($f/2$). It is supported in its cell by 18 axial pneumatic bellows, three axial locators, four lateral bellows, and three lateral locators. Support for the tertiary mirror and light baffle is through the 20 cm core of the primary to the mirror cell.

The non-oscillating secondary mirror, also of solid CER-VIT, is a 23 cm diameter hyperboloid. It is figured to yield an overall focal ratio of $f/13.5$ (1230 cm) at final focus. The mirror and step-focus drive are held in the head ring by four orthogonal Invar spiders. Some types of radiometry and photometry employ a wobbling secondary mirror as an efficient means of space filtering. Accordingly, an alternate secondary mirror assembly with an 18.7 cm aperture is provided that can be oscillated at frequencies up to 40 Hz, with throws from zero to ± 2 arc-minutes. The direction of throw of the wobbling secondary also may be rotated in flight over a 150 degree range.

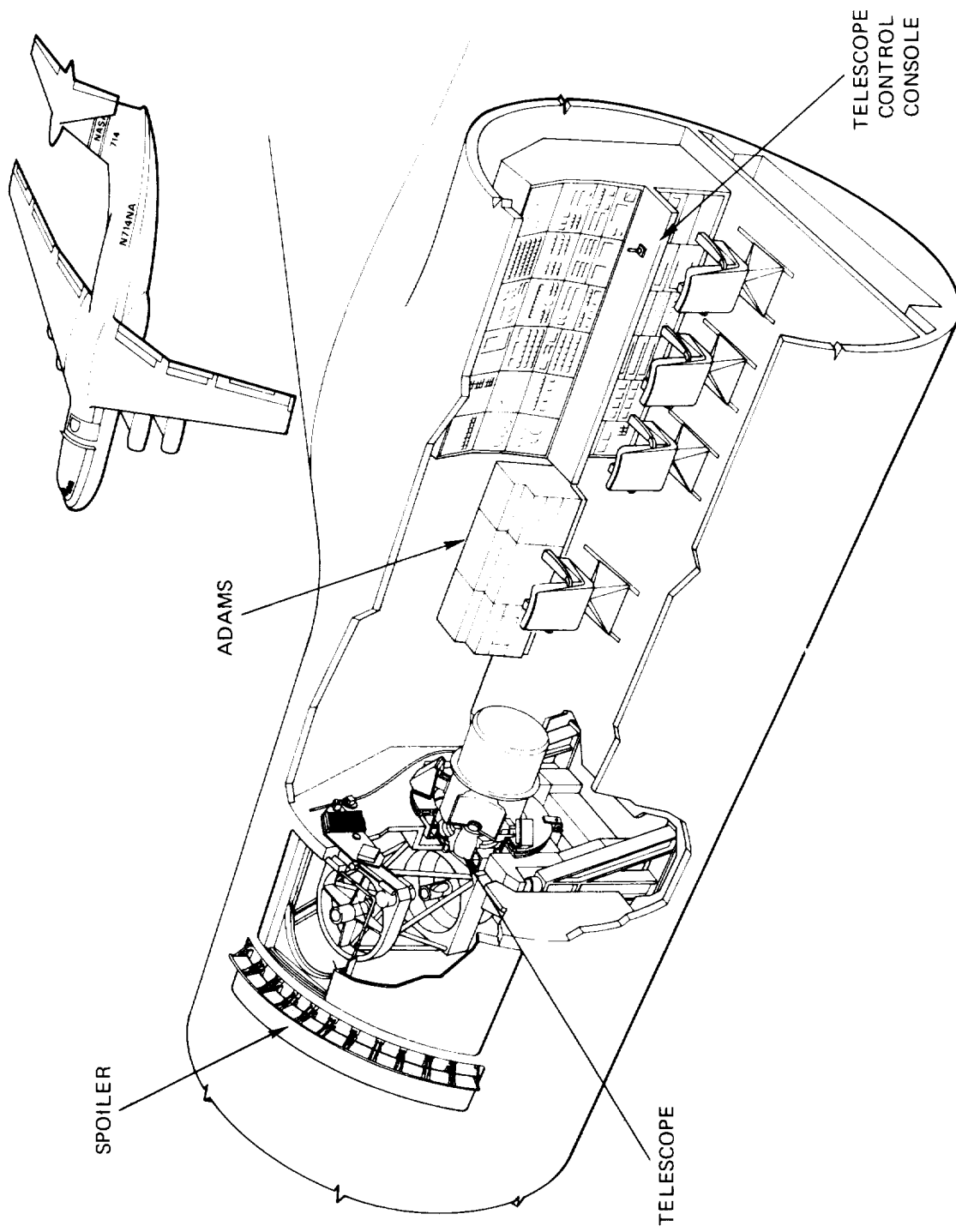


Figure I-1 Airborne Observatory

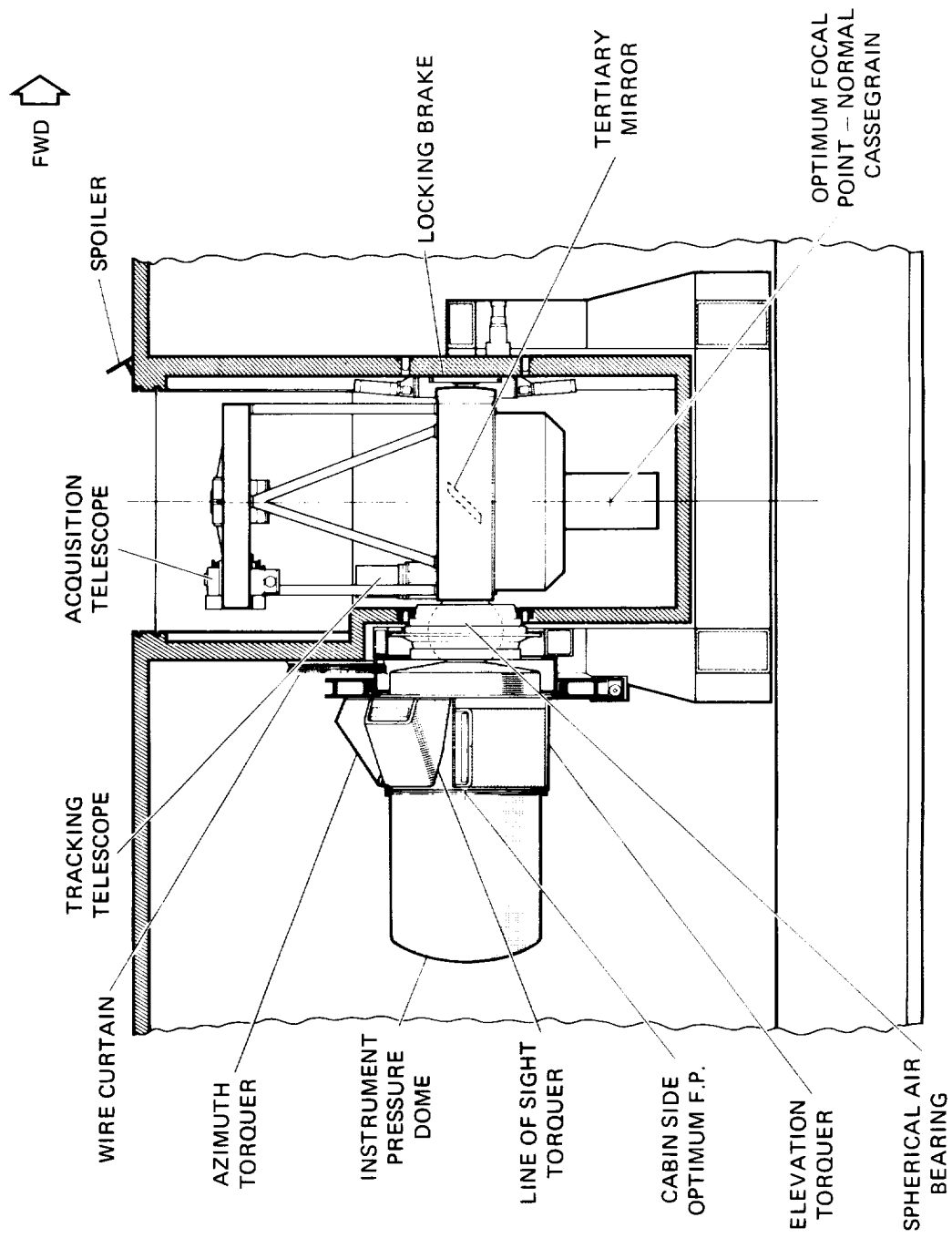


Figure I-2 Telescope Installation View Outboard

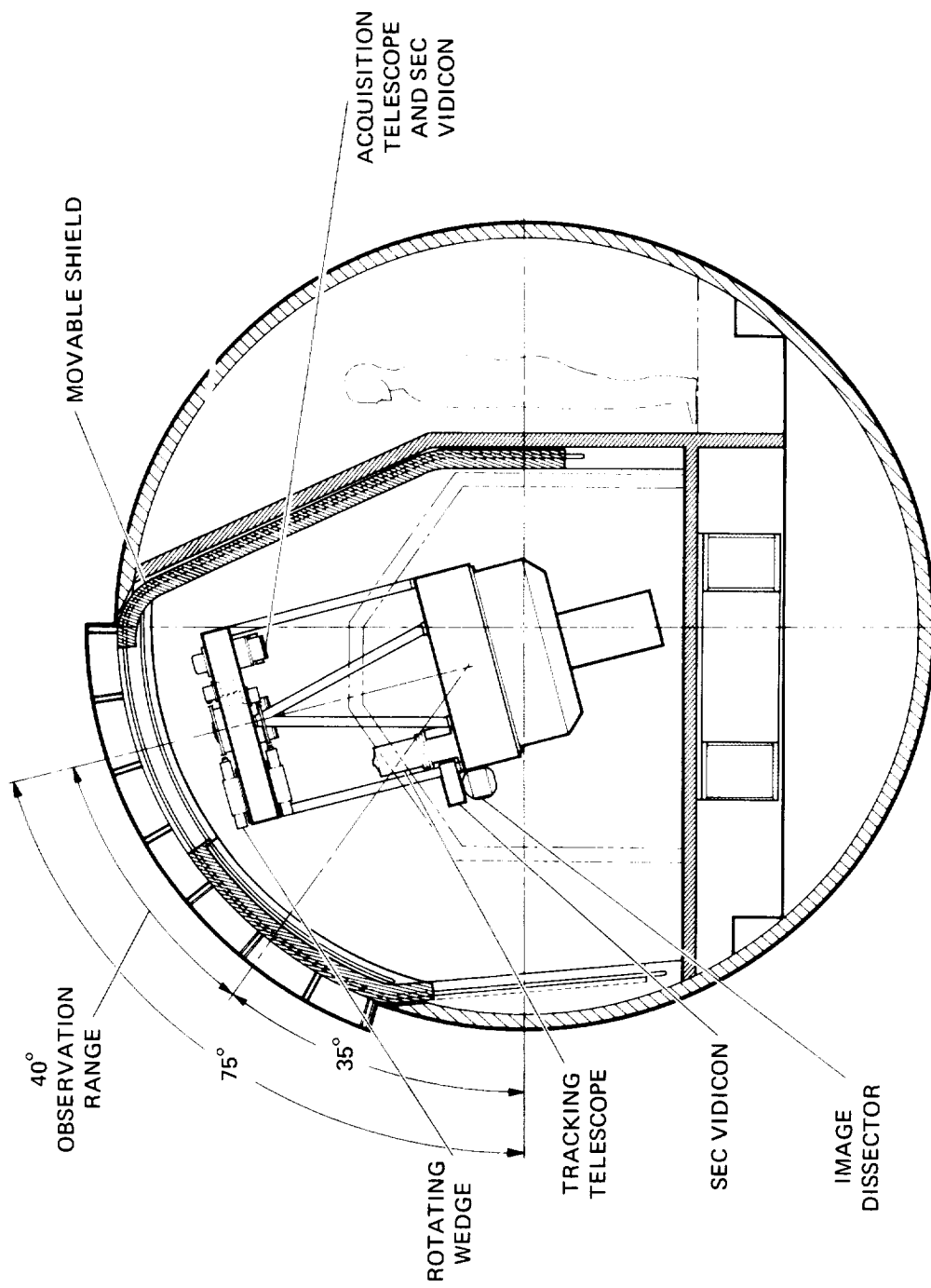


Figure I-3 Telescope Installation View Forward

In addition, the telescope may be used in a computer-controlled, raster-scan mode to search for infrared sources, or to map extended regions. Details of raster-scanning operation are available from the Facility Manager.

In the bent mode, optimum focus falls 81.3 cm from the center of the air bearing (2.5 cm aft of flange position 2). Total back focus is 76 cm from flange position 1. Immediately behind the air bearing there is a rotating disk (Figure I-4) that has five index positions interposing four different pressure carrying IR transmitting windows and one open port position. Details of window materials and properties are given in Table I-1. With any one of the pressure windows in the optical path, instruments can be operated in the cabin environment. In the open port position, the detector package can be operated in the cavity environment, provided a pressure vessel (supplied with the telescope) is installed around the detector package, or provided the detector package itself is designed to carry the operating pressure differential. A fail-safe interlock prevents accidentally rotating the disk across the open-hole position when a pressure differential exists.

TABLE I - 1
PRESSURE WHEEL WINDOW CHARACTERISTICS

<u>POSITION NUMBER</u>	<u>MATERIAL</u>	<u>THICKNESS (cm)</u>	<u>GRADE</u>	<u>TRANS. RANGE</u>	<u>PEAK λ</u>
1	Fused Silica	1.30	Suprasil W-1	0.18-3.6 μ	0.3-2.0 μ
2	Calcium Flouride	1.32	-----	1.0-7.0 μ	4.5 μ
3	Cesium Iodide	1.60	-----	5.0-50.0 μ	12 μ
4	Polyethylene	1.30	Type III High Density	40-2000 μ	100 μ
5	Blank, Open Port	----	-----	-----	----

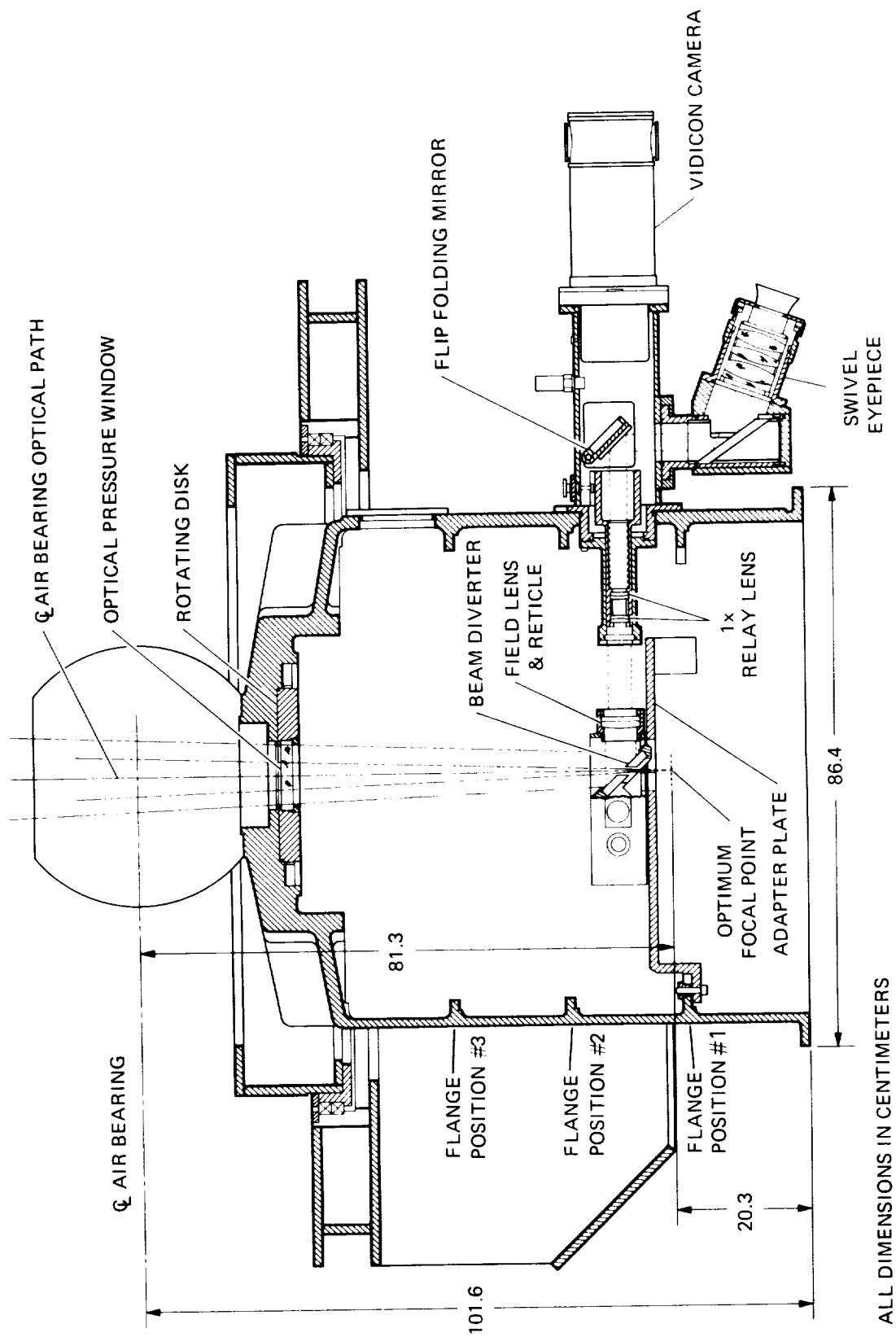


Figure 1-4 Focal-Plane Monitor

A focal-plane monitoring system (Figure I-4) is housed within the mounting flange at the bent Cassegrain optimum focal position (flange position 2). The focal-plane monitor functions as a visual aid to the observer permitting direct viewing of the main telescope focal plane, or portions thereof, either through an eyepiece or by displaying the image of the focal plane on a video monitor located on the control console. This capability is required in the process of target acquisition and tracking. The beam-directing mirror can be moved by the observer either by using the controls on the control paddle, while looking through the eyepiece, or by controls on the console while viewing the image on the video monitor. The diagonal mirror mechanism can be retracted to one side when not in use. Several different diagonal mirrors are available with holes permitting IR throughput to the detectors. The angular diameter of the holes in the diagonal mirrors are large enough to pass fields of view of 0.5, 1, 2, 4, 5, 7 arc-minutes without vignetting.

The cabin-side mounting flange can support up to 182 kg of observational equipment with a center of mass 61 cm from flange position 2. After installation of experimental apparatus, the telescope system is balanced by removing sufficient counterweights from the perimeter of the instrument dome mounting flange. Balance is achieved when the instrument plus counterweights exactly offset the telescope weight across the air bearing. After initial balance, sensors located on each axis will detect any small imbalances that may occur (e.g., cryogenics depletion) and automatically move counterweights to rebalance the system.

To prevent drag on the air bearing, most electrical, vacuum, and cryogenic lines are brought from the aft cavity wall to the mounting flange and telescope as a single bundle or curtain. The curtain is servo controlled to follow the telescope's motion in elevation. Lines to the telescope are passed, near the periphery, through the aperture in the air bearing.

Conventional Cassegrain focus is available with the tertiary mirror removed. Up to 45 kg of equipment can be mounted to the flange behind the primary mirror cell. However, because of space limitations between the back side of the primary mirror and the cavity floor and walls, the envelope dimensions of the instrument package are limited as discussed in Section II-2.2. In addition, instruments mounted at Cassegrain focus must be operated remotely as there can be no direct access to the cavity during flight. Installation and electrical interconnection constraints are outlined in Section II-3.3.

The air-bearing support effectively reduces rotational vibrations potentially transmitted from the airplane. Translatory vibrations are attenuated by an active isolation system which has an upper cutoff frequency of 3 Hz. They support the telescope at four points forming a plane that contains the center of gravity

of the telescope, thus eliminating cross coupling of linear vibrations. The telescope structure has a natural frequency of greater than 30 Hz, while the air bearing has a natural frequency of greater than 150 Hz. Table I-2 is a summary of pertinent telescope design characteristics.

2.0 OPTICAL PERFORMANCE

The AIRO is capable of operating at the ambient pressures and temperatures encountered between 15.2 km and sea level. However, the optical quality of the system is optimized for an average altitude and temperature of 13-15 km and 200°K respectively. Exclusive of aircraft boundary-layer effects on seeing, the overall optical quality is such that at least 85 percent of point-source incident radiation at 0.55 μm is contained within a 1 arc-second blur circle. With the 20.3 cm diameter non-oscillating secondary, the area of obscuration is approximately 8 percent; taking into account effects from the spiders, etc., the system is diffraction-limited at about 1 μm .

Currently, a slightly undersized (18.5 cm diameter) aluminized silicon mirror is mounted on a dual solenoid mechanism oscillating at a maximum frequency of 40 Hz. A second generation oscillating system is under development with a capability of square wave operation at speeds faster than 100 Hz. Appropriate baffles and stops minimize scatter and side-lobe response, and the edges of the spiders facing the primary are gold flashed. Development of a family of mirrors is planned for installation as needed on the oscillating secondary mount. Uncoated pure aluminum is deposited on the primary mirror, and alternate secondary and tertiary mirrors with either aluminum or gold coatings are provided. With all aluminum-coated optics, the threshold visual magnitude at optimum focus is $m_v \geq 17$.

3.0 TELESCOPE ENVIRONMENT CONTROL

Beside the use of Invar and CER-VIT to minimize thermal flexure, the telescope cavity and the instrument pressure dome can be precooled to near the predicted stagnation temperature at the observing altitude. While on the ground, a portable mechanical refrigerator is used to cool the cavity walls and to trap any water vapor inside the cavity. A slight positive pressure is maintained within the closed cavity to avoid ingestion of water vapor or dust from outside. In-flight cooling is provided by an on-board system.

SUMMARY OF TELESCOPE DESIGN CHARACTERISTICSOptical Data

PARABOLIC F/2 PRIMARY MIRROR

20 CM DIAMETER HYPERBOLIC FIXED SECONDARY MIRROR

18.54 CM DIAMETER OSCILLATING SECONDARY MIRROR

BENT-CASSEGRAIN FOCUS:

OPTIMUM FOCAL RATIO F/13.5

MAX. FIELD OF VIEW: 14 ARC-MIN

70 CM BACK FOCUS (FIXED SECONDARY MIRROR)

90 CM BACK FOCUS (OSCILLATING SECONDARY MIRROR)

NORMAL CASSEGRAIN FOCUS:

OPTIMUM FOCAL RATIO F/10

MAX. FIELD OF VIEW: 20 ARC-MIN

35 CM BACK FOCUS (FIXED SECONDARY MIRROR)

50 CM BACK FOCUS (OSCILLATING SECONDARY MIRROR)

AREA OBSCURATION OF PRIMARY MIRROR: 8 PERCENT (FIXED SECONDARY MIRROR)

AREA OBSCURATION OF PRIMARY MIRROR: 6 PERCENT (OSCILLATING SECONDARY MIRROR)

85 PERCENT OF VISIBLE POINT SOURCE RADIATION IN 1 ARC-SECOND BLUR CIRCLE

ALL REFLECTING ELEMENTS ARE ALUMINUM COATED WITH NO OVERCOAT

ALTERNATE SECONDARY & TERTIARY MIRRORS ARE GOLD-COATED

Mechanical Data

MAIN OPTICAL ELEMENTS: CER-VIT

OPTICAL SUPPORT STRUCTURE: INVAR

NATURAL FREQUENCY OF TELESCOPE: APPROXIMATELY 39 Hz

BAND WIDTH OF GYRO-TORQUER SYSTEM: 8 Hz

CUT-OFF OF SEMI-ACTIVE VIBRATION ISOLATION SYSTEM: 3 Hz

CAVITY AND TELESCOPE CAN BE PRE-COOLED TO 200° - 220° K

BENT-CASSEGRAIN MOUNTING FLANGE CAN SUPPORT 182 KG (400 lb) INSTRUMENT

NORMAL CASSEGRAIN MOUNTING FLANGE CAN SUPPORT 45 KG (100 lb) INSTRUMENT

Tracking and Stabilization Data

DEMONSTRATED TRACKING ACCURACY (OPEN PORT): 6 ARC-SECONDS PEAK-TO-PEAK
 FOR AT LEAST 30 MINUTES
 DRIFT BETWEEN TRACKER TELESCOPE AND MAIN TELESCOPE AXIS: 2 ARC-SEC/HR
 JITTER: LESS THAN 2 ARC-SEC
 3 GAS BEARING GYROS (0.05 ARC-SEC/SEC DRIFT RATE) AND 4 DC SEGMENTED
 TORQUE MOTORS (3.25 KG-M CONTINUOUS, OVER 9.1 KG-M PEAK)
 7.6 CM ACQUISITION TELESCOPE WITH 8° F.O.V. RELAYED TO CONSOLE BY VIDICON
 CAMERA
 15 CM TRACKING TELESCOPE WITH 40 ARC-MIN F.O.V. RELAYED TO CONSOLE BY
 VIDICON CAMERA
 ROTATING OPTICAL WEDGES IN FRONT OF TRACKER FOR OFFSET TRACKING OVER 4°
 HALF-ANGLE CONE
 I.T.T. F-4012 IMAGE DISSECTOR FOR TRACKING POINT AND EXTENDED SOURCES
 (M_V RANGE = -26 to +6)
 FOCAL-PLANE MONITOR AT BENT-CASSEGRAIN FOCUS FOR CONTINUOUS-OR-COMMAND
 VIEW OF FOCAL PLANE EITHER FROM THE TELESCOPE OR FROM THE CONSOLE

System Features

TV DISPLAY AT CONSOLE AND TELESCOPE OF ACQUISITION, TRACKING AND MAIN
 TELESCOPE FIELD OF VIEW
 CONSOLE DISPLAY AND CONTROL OF TELESCOPE OPERATION AND FLIGHT PARAMETERS
 VITAL TELESCOPE FUNCTIONS AND FLIGHT PARAMETERS RECORDED ON DIGITAL DATA
 LOGGING SYSTEM
 CONTROL PADDLE AT TELESCOPE FOR FOCUS, SLEWING, OFFSET TRACKING
 PROGRAMMABLE DIGITAL COMPUTER ON AIRCRAFT FOR INVESTIGATOR'S DATA LOGGING
 AND REDUCTION
 GROUND LABORATORY CONTAINING TELESCOPE "SIMULATOR" AND OTHER EQUIPMENT
 TO EXPEDITE INSTALLATION ON TELESCOPE AND AIRCRAFT
 VACUUM PUMPING SYSTEM FOR INVESTIGATOR'S CRYOGENIC DEWAR

4.0 TELESCOPE STABILIZATION AND IMAGE ACQUISITION

The demonstrated image stability at the focal plane is 6 arc-seconds peak-to-peak for at least a 30-minute interval. Even in light turbulence, drift between the tracking systems and the main focal plane does not exceed 1 arc-second during this interval.

Four stages of stabilization are utilized to achieve this accuracy, the *first stage* being the C-141 itself. By tuning the autopilot for a known airspeed, altitude, and payload, excursions in pitch and yaw can be held to within $\pm 0.25^\circ$ and roll to within $\pm 0.5^\circ$. Even in light turbulence, the autopilot can limit aircraft excursions to $\pm 2^\circ$. The telescope tracking and stabilization systems overcome these latter oscillations. To view an object at a different azimuth, the airplane is simply turned to a heading that will put the new object within the azimuthal field of view.

The air bearing is the *second stage of telescope stabilization*. Floating on a thin film of air, the bearing is an almost frictionless support. The gap between the bearing and its housing is $18\mu\text{m}$ and air flow is nominally $7080\text{ cm}^3/\text{s}$ at a pressure of 19 atm. Air is scavenged and vented overboard on the right side to avoid contamination of the cavity. Moreover, the bearing's spherical cross section makes possible three-axis inertial stabilization. Rotation about the axis which corresponds to the line of sight in inertial space is actually a rotation about the center of the air bearing and not a rotation about the telescope's geometric axis (Figure I-2). This arrangement will cause a small drift rate in rotation about the main telescope's line of sight when the auxiliary tracking telescope is operated in the offset mode. The drift rate increases with offset from the center of the main telescope's field of view, reaching a maximum of 0.3 arc-second/minute at full offset ($\pm 4^\circ$ half-angle cone) of the tracking telescope. The drift rate should be negligible for most observations, but the rate can be reduced even further by occasionally biasing the tracking controls.

Third-stage stabilization is provided by three gas-bearing gyroscopes (drift: 0.05 arc-sec/sec) and their associated torque motors; each gyrotorquer is tied to one of the telescope's three axes (Figure I-2). This system serves as an inertial reference platform for the air bearing. The dc-segmented torque motors are not mechanically coupled between the air bearing and its housing, thus no static friction is induced into the system. Torque is applied to the telescope by varying the electrical field between the rotor, which is part of the air bearing, and the stator, which is part of the air bearing housing. The torque motors can be overridden manually to slew the telescope.

The *fourth stabilization stage* is an image-tracking system composed of a 15 cm aperture, f/5 telescope, and an image dissector. This system removes gyro drift and other slow random motions. The unit is mounted to one side of the main telescope frame and is bore-sighted to its optical axis. Error signals generated in the image dissector (ITT F-4012) are fed back into the gyro control loops. The image dissector is capable of tracking sources ranging from a point up to 33 arc-minutes in diameter over a brightness range from $m_V = -27$ to $m_V = +6.0$. A Westinghouse STV 606 SEC Vidicon (Figure I-3) shares the energy throughput to relay 10 percent of the telescope's maximum 40 arc-minute field of view to the video monitor on the control console. Drift between the tracker and the main telescope optical axis is less than 2 arc-seconds in a 30-minute interval. The line-of-sight axis drift is corrected manually by use of "joy-stick" control from either the console or from the Investigator's control paddle.

A pair of 2° rotating prisms mounted in front of the tracking telescope (Figure I-3) is used to offset-guide over an 8° circular field. Objects fainter than the threshold limit of the image dissector ($m_V = 6$) may be centered in the main telescope by rotating the two wedges, either together or separately, which optically offset the tracker's line of sight with respect to that of the main telescope. Rotation of both prisms about the tracker's line of sight results in an apparent field rotation in the tracking telescope. Rotation of the prisms with respect to each other results in a radial displacement of the tracker's field with respect to the field in the main telescope. The ADAMS computes and constantly updates the offset angles, and controls the rotation of the prisms.

To reduce color dispersion, each prism is composed of two wedges of different optical materials (TiF₂ and Schott KZFS-7). This combination yields a 2 arc-second secondary spectrum on-axis and an 8 arc-second spectrum at 4° offset. The secondary spectrum has negligible effect on the image dissector since it can area-track the dispersed image near the limit of offset. Variations in the object's spectral class and color temperature contribute less than 1 arc-second uncertainty of offset angle. The rotating wedge system can be reindexed to coalign the tracking telescope with the main telescope's focal plane.

A 7.6 cm diameter refracting telescope mounted on the main telescope frame is used to acquire objects in the tracking telescope. This acquisition telescope has an 8° field of view that is relayed to a monitor on the control console by a Westinghouse STV 606 SEC Vidicon. Like the tracking telescope, the acquisition system has a threshold magnitude of $m_V = 6$. Refer to Figures I-6 through I-12 for illustrations of tracking modes and characteristics.

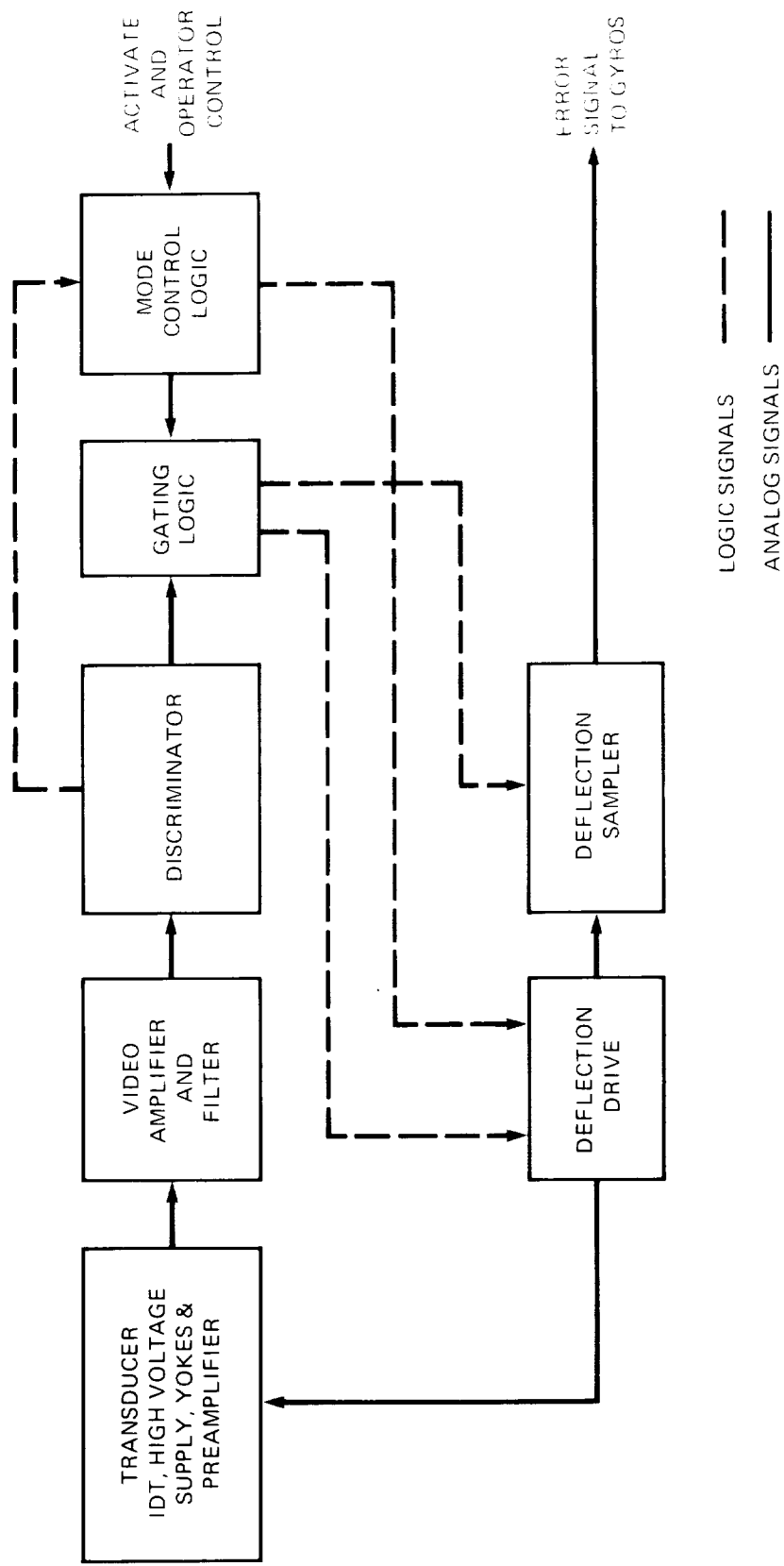


Figure I-5 Tracking Subsystem Block Diagram

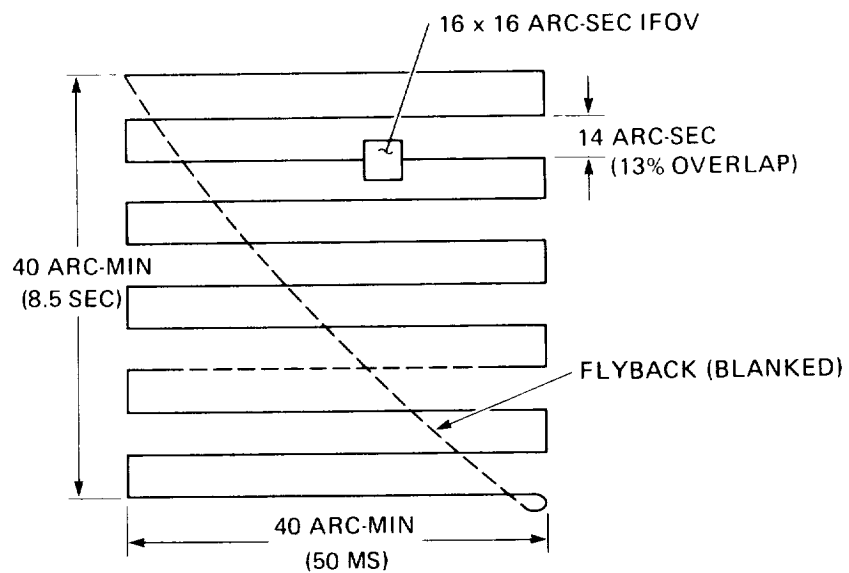


Figure I-6 Acquisition Field-Mapping-Mode Scan Pattern

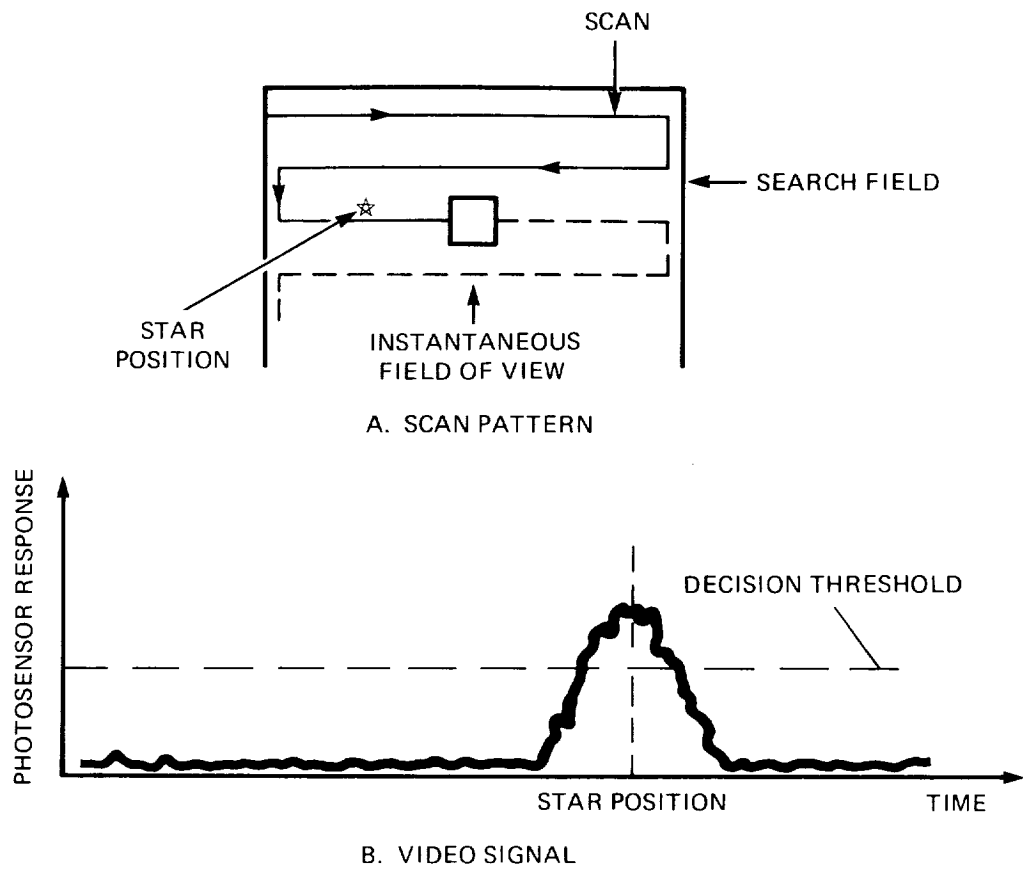


Figure I-7 Search-Model Scan and Video Signal

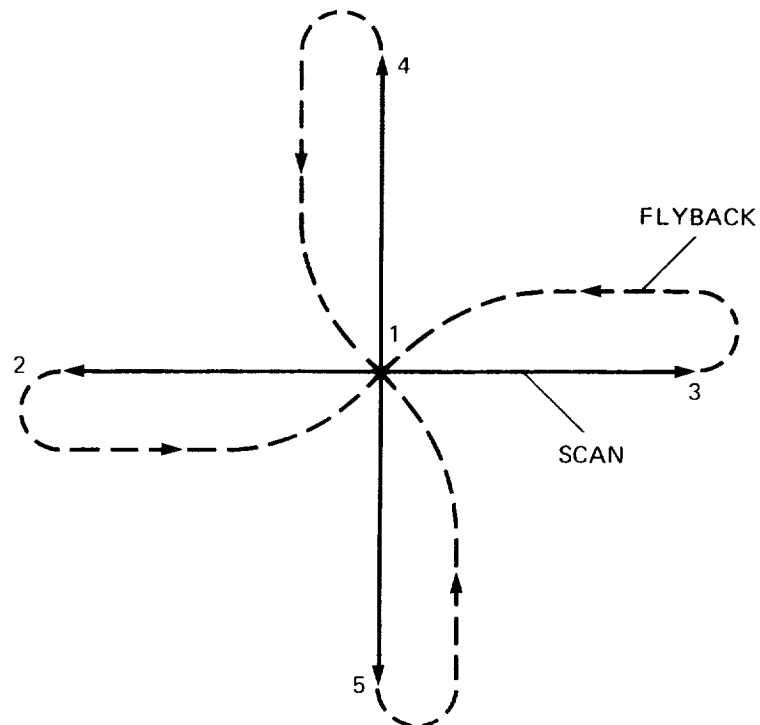


Figure I-8 Track-Scan Pattern

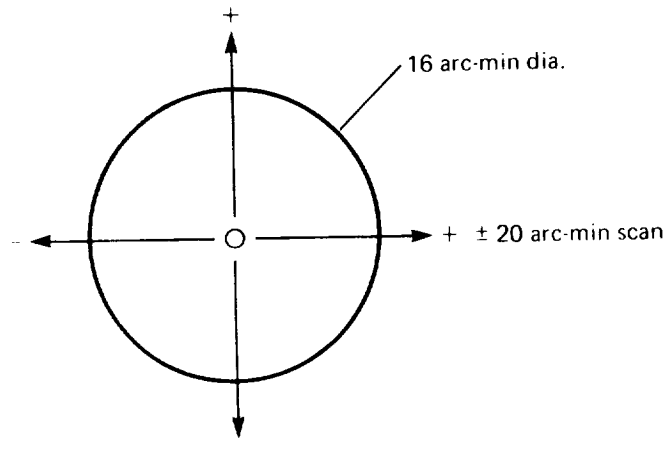


Figure I-9 Extended-Target Tracking

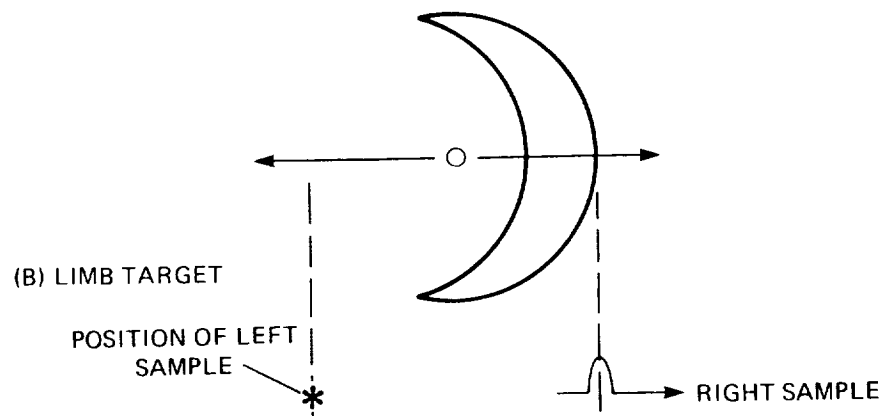
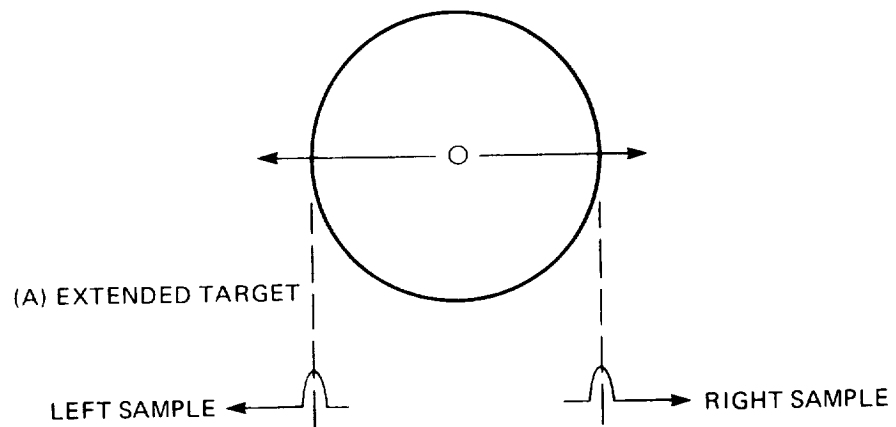


Figure I-10 Extended vs Limb Sampling

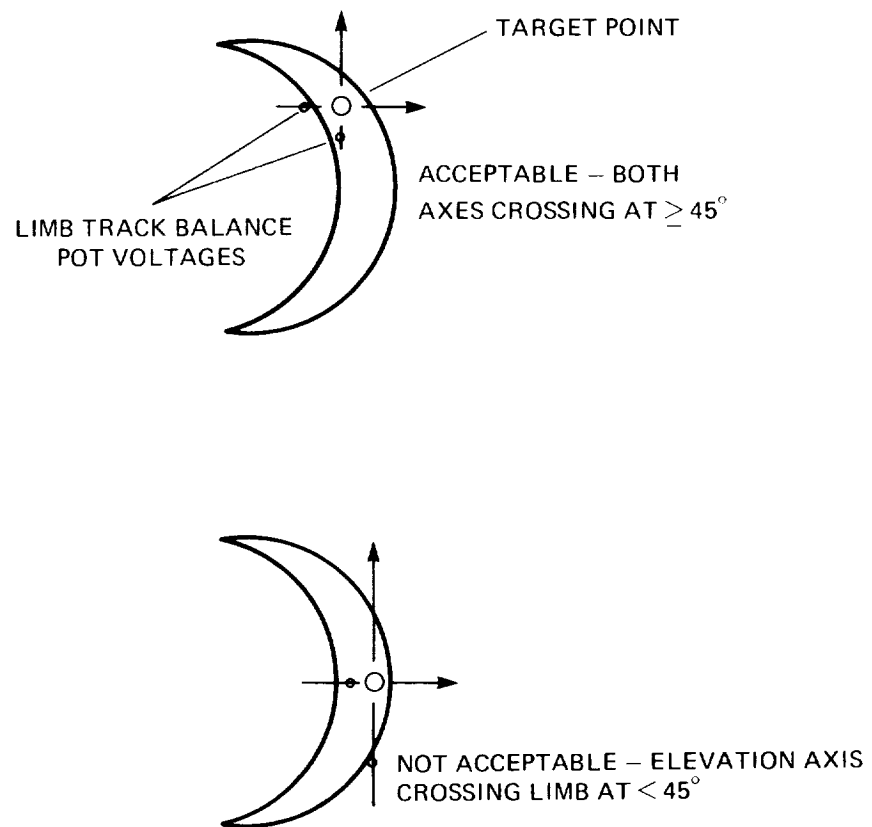


Figure I-11 Limb Track Limitations

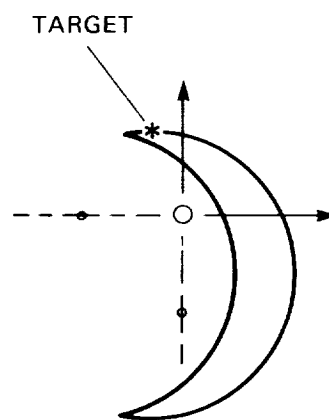


Figure I-12 Limb Tracking Target Near Poles

5.0 ELECTRICAL POWER

Refer to Section II-2.3.

6.0 TELESCOPE SUPPORT SYSTEMS

6.1 AIRBORNE DATA ACQUISITION AND MANAGEMENT SYSTEM (ADAMS)

The ADAMS computer is a vital component of the AIRO since most of the ancillary telescope systems and several of the aircraft systems react with the telescope through it. It provides a versatile data management system to coordinate experiment requirements with the operation of the telescope and with the aircraft.

The functions of ADAMS are to (Refer to Figure I-13):

- a. Acquire high-speed primary experiment data in both analog and digital form.
- b. Acquire secondary and housekeeping data.
- c. Log all data continually in raw data form on digital magnetic tape.
- d. Provide quick-look capability using the line printer or other peripheral device.
- e. Perform co-adding of interferograms and determine statistics of this process accurately enough to determine when a sufficient amount of data have been gathered.
- f. Perform Fourier transform of interferograms in order to compute spectra in flight.
- g. Display spectra on a cathode-ray tube.
- h. Control experiment functions in accordance with the Investigator's requirements.
- i. Facilitate integration of Investigator's software into the system.
- j. Provide non-real time processing of Investigator's data, if required, on an emergency basis in the field, or as one element of flight planning.
- k. Control telescope articulation and scanning in synchronism with experiments and according to various methods of motion as determined by the Investigator and the Mission Director.
- l. Perform the following ancillary computations as required:
 - (1) Convert raw data to engineering parameters for quick look.
 - (2) Clock data and give periodic static checks.
 - (3) Perform diagnostic computations on command.
 - (4) Provide an in-flight planning capability to accomplish the following tasks:

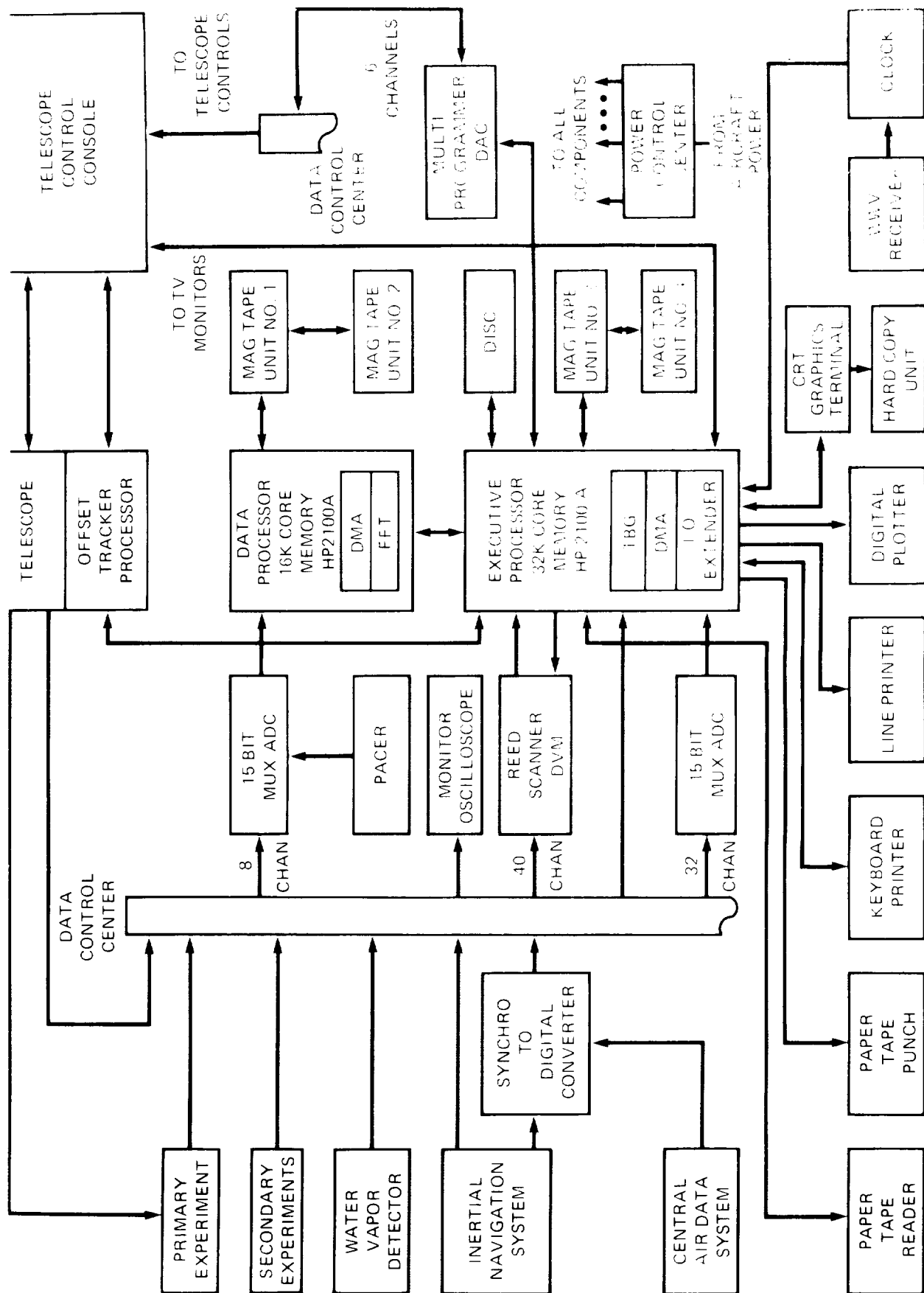


Figure I-13 Adams Block Diagram

- (a) Given a celestial object or celestial coordinates, determine aircraft and telescope parameters for acquisition and tracking.
- (b) Determine maximum tracking time possible and the optimum conditions for tracking within the flight constraints of the aircraft.
- (c) Compute distance and flight time to return to base.
- (d) Keep an accounting of system parameters for a historical record to help in system development.

6.2 HELIUM PUMPING SYSTEM

Two independent cryogen gas vapor pumping systems are available. The larger system of 500 liters per minute capacity, is based on a Welch model 1397 2-stage vacuum pump. A smaller system, 100 liters per minute, is built around a Welch model 1402 pump.

The vacuum lines are permanently installed between the pumps and their respective manifolds and gauges with flexible vacuum rubber tubing providing the interface to instrument dewars. This vacuum service is available at either of the telescope instrument mounting locations. Each Investigator can choose the pumping system best suited to his needs. Normally, the other pump will be removed to reduce unnecessary weight on the aircraft.

6.3 WATER VAPOR OBSERVATIONS

6.3.1 General

The most important single reason for flying an infrared telescope in an aircraft is to permit operation above as much of the obscuring water vapor as possible. While orders of magnitude of improvement in IR transmission are possible at aircraft altitudes, there is still known to be considerable variability in the spectral transmittance of the earth's atmosphere over long stratospheric slant paths. Therefore, the AIRO will carry several water vapor sensors to provide the astronomer with information useful for the correct analysis of received IR flux levels.

6.3.2 Water-Vapor Radiometer

The Water-Vapor Radiometer is an ancillary scientific experiment installed in the sextant port on the flight deck. It has a two-fold mission:

- a. It provides real-time data inputs to the ADAMS from where it is subsequently available to the Investigator as a readout in terms of microns of precipitable water remaining in a column of atmosphere directly above the aircraft. This information will aid in the correct interpretation of infrared flux levels received from astronomical sources.
- b. As a meteorological research tool, it will regularly obtain upper-atmosphere water-vapor data as a function of latitude, season, and altitude whenever the C-141 AIRO is airborne.

The Water-Vapor Radiometer (WVR) has the following characteristics:

Detectors: Cu:Ge and tri-glycine-fluoride

Spectral Band: 18.5 - 30.0 μm

Field of View: approximately 20°

Radiance Detectivity: 10^{-7} W/cm²/ster

Bandwidth: approximately 0.1 Hz

Water Detectivity: 10^{-5} g cm⁻² (\pm 0.1 μm)

Instrument operation and data analysis is under the direction of Dr. Peter M. Kuhn of the National Oceanic & Atmospheric Administration (NOAA).

6.3.3 Far-Infrared Atmospheric Interferometer

This instrument measures atmospheric variances of water, ozone, and nitrous oxide, and provides correlative data for the Water-Vapor Radiometer. The instrument consists of a far-IR interferometer and 0.3°K bolometer, and is supported by its own data recording system. Data recording, reduction and interpretation are the responsibility of Dr. Russell J. Donnelly of the University of Oregon. The instrument is located in the top aft portion of the aircraft at F.S. 1178.

6.3.4 Frostpoint Hygrometer

A determination of the mixing ratio (the weight of water in a given weight of dry air) of the air mass the C-141 AIRO is passing through will be made under the direction of Dr. J. Mastenbrook of the Naval Research Laboratory. Two outputs will be available:

- a. Mixing ratio in parts per million.
- b. An exact measure of the frostpoint temperature.

6.4 CRYOGENIC SOURCE

NASA/ARC maintains a supply of liquid helium and liquid nitrogen to fill Investigator dewars. Liquid helium dewars inside the pressure dome or installed at normal Cassegrain focus cannot be replenished during flight. Investigators requiring other cryogens should discuss their needs with the Facility Manager in advance.

6.5 ENVIRONMENTAL CONTROL SYSTEM

6.5.1 General

In the changing ambient environment from ground level to the operating altitude of the C-141 Airborne Infrared Observatory, the telescope may be subjected to temperatures ranging from a high of 41°C to a low of -73°C and pressures of ground ambient to 110 mm/Hg. To preclude this changing environment having an adverse effect on the telescope thermal-structural stability it is essential that the telescope be gradually preconditioned and maintained at the expected operating temperature environment. If required, the system must also be gradually returned to ground-ambient conditions upon completion of an observing mission. Since the telescope is designed to operate in the open-port mode, the system is allowed to follow ambient-pressure changes. However, the instabilities associated with rapid temperature changes such as thermal drift, thermal shock, and condensation, are severe and are most easily overcome by gradual temperature conditioning. This is the function of the Environmental Control System (ECS). Currently, the basic system concept utilized for environmental control is that of closed-loop air recirculation. The air is continuously recirculated through the conditioning unit, providing heated or cooled air to the telescope cavity. The system involves a small-capacity aircraft unit and a large-capacity ground-support unit, working together to perform the ground preconditioning. The aircraft unit maintains the cavity temperature, humidity, and a slight positive pressure when the facility is airborne.

6.5.2 System Capacity

In a ground-ambient environment of 41°C and 100 percent relative humidity, the environmental system is capable of dehumidifying and cooling the cavity to -54°C in about a four-hour period. The primary mirror has an approximate 2-hour lag in the cooldown or warmup cycle. This represents a heat load of approximately 21,400 kilogram-calories/hr. and is obtained by the combined operations of the Aircraft Refrigeration Unit (ARU) and the Ground Refrigeration Unit (GRU). For taxiing, runway hold, and airborne operation,

the ARU alone is capable of maintaining the cavity at -54°C (a mean heat load of about 5,800 kilogram-calories/hr). The ARU also delivers about 283 liters per minute of dry sub-cooled makeup air to the telescope cavity such that the cavity, with shield closed, is maintained at a slight positive pressure relative to outside-ambient pressure. A 5,000 Watt electric heater is used for system warmup and fine temperature control.

6.5.3 System Operation

At a given time prior to the departure of a mission, the Ground Support Unit is connected to the aircraft. The Aircraft and Ground Support Units, acting together, dehumidify the air within the cavity to a point sufficiently lower than ambient dewpoint to permit the initiation of the cooling cycle. The dewpoint within the cavity remains at a point lower than the telescope-equipment temperature throughout the operation of the system to prevent water or ice condensation. After the cavity and the associated telescope equipment are cooled to the set temperature, the Ground Support Unit can be disconnected. The Aircraft Unit holds the cavity and telescope-equipment temperature, the dewpoint within the cavity, and the cavity positive pressure as required through take-off and subsequent airborne activities. The ARU is turned off once the aperture door is opened.

At the conclusion of observing operations, the system controls can be switched to the warm-up cycle. Cavity positive pressure and cavity dewpoint are maintained below telescope-equipment temperatures as the aircraft descends and the equipment temperatures gradually rise. Once on the ground, the Ground Support Unit is re-connected to the aircraft assisting the Aircraft Unit in maintaining dewpoint and positive-pressure control within the cavity. When the primary mirror temperature has risen above ambient dewpoint outside the aircraft, the environmental control system is shut down and secured allowing access to the cavity and telescope system.

6.6 INTERCOMMUNICATION SYSTEM

The C-141 AIRO Intercommunication System (ICS) provides 13 strategically-located stations for convenient communication between primary Investigators, secondary Investigators, Mission Director, and the Telescope Systems Operators. Figure I-14 shows the various station locations within the aircraft.

6.6.1 System Operation

The Mission Director Station is the master or control station for the ICS. All voice communications flow through, are controlled by

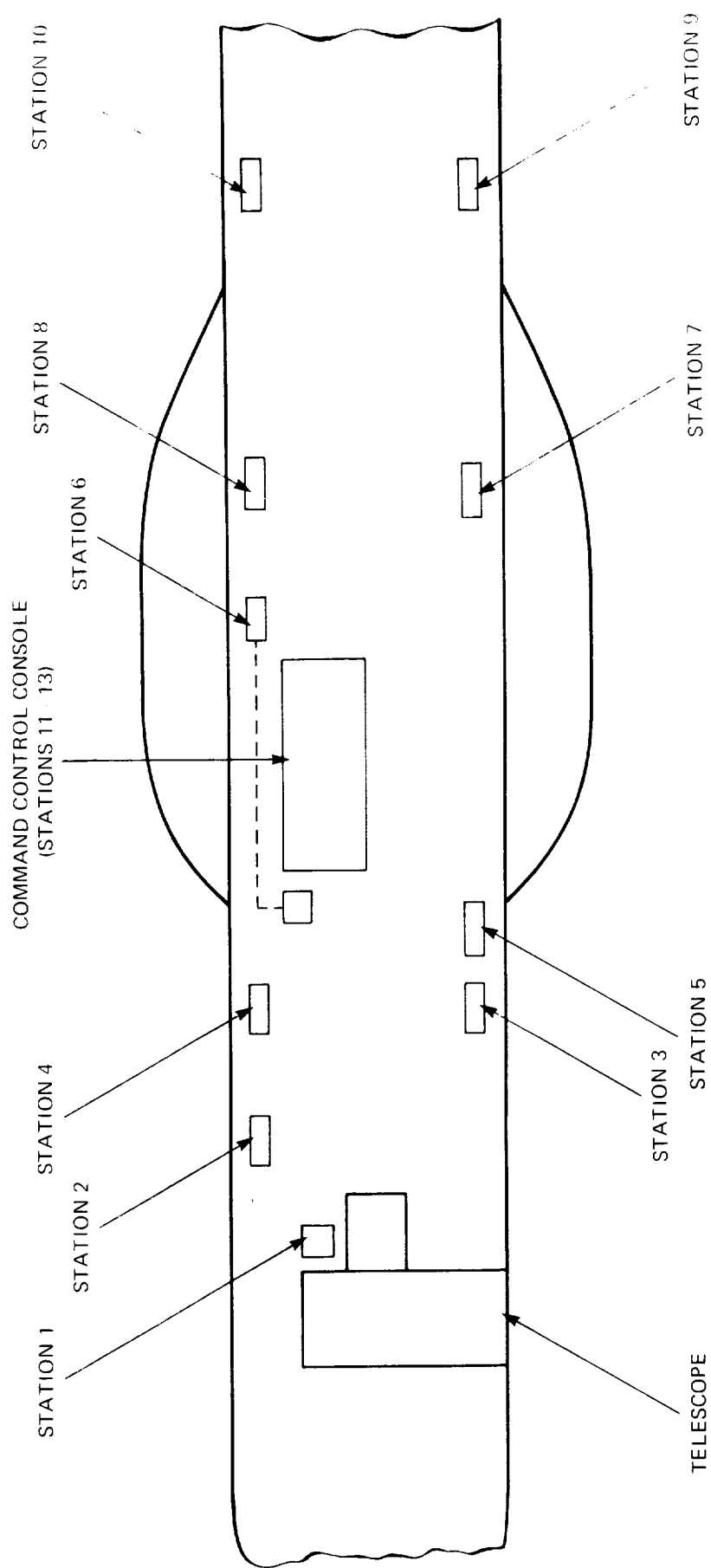


Figure I-14 Investigator's Intercommunication System Station Locations

and may be monitored at this station. Any one of the Investigator stations may be placed on either of two lines. The Mission Director Station has, in addition, the capability to separately communicate with either of the two telescope control operators and to flight deck personnel. The Mission Director can communicate via aircraft radio as well. All stations have call buttons which, when operated, signal the Mission Director.

6.7 AIRO SIMULATOR

The telescope simulator at Ames Research Center will provide the necessary facilities to enable each Investigating Team to ground-test its apparatus under conditions which will closely simulate the environments encountered during flight and determine the physical and electrical interface compatibility between the instrument, equipment rack, cables and the AIRO.

This simulator system will be completed sometime during the fiscal year 1975, at which time this handbook section will be updated with full information on the facility. However, environmental test and evaluation facilities are available at ARC which afford the Investigator the opportunity to test his instrument under the simulated flight conditions of temperature and altitude. In addition, facilities exist for shock and vibration tests. Use of these facilities may be obtained by contacting the Facilities Manager, and should be coordinated as early as possible to minimize scheduling problems.

The simulator facility will provide mounting flanges identical to those found at the various focal positions on the telescope. A variety of infrared sources will also be available so that the Investigator can check, at his option, alignment, filter transmission and other vital parameters of the instrument he is installing on the AIRO. Elements of the ADAMS data system, with which an Investigator might wish to interface, will be available in the simulator lab so that all power, control and signal cabling can be checked. The instrument will attach to one side of a thermal-vacuum chamber that can be cooled and evacuated to simulate environments at altitudes to 15 km.

It is anticipated that these support facilities will be available to an Investigating Team during the two-week period just prior to a flight series. If an Investigator has any reason to expect very severe interface problems with his apparatus, he should advise the Facility Manager at an early date so that arrangements can be made to expedite a solution.

7.0 ON-BOARD FACILITIES AND ACCOMMODATIONS FOR INVESTIGATORS

7.1 FLOOR PLAN

The location of the telescope, consoles and ancillary equipment is shown in Figure I-15, a plan view of the C-141 AIRO.

Personnel access to the cabin is through doors located in the sides of the cabin, one on the starboard, and two on the port. Bulk equipment can be loaded in the cabin through the clamshell cargo door and ramp on the underside of the empennage (see Figure I-16). In addition to the doors, the main cabin is equipped with four emergency exits (see paragraph I-7.2.7). The door located on the port side forward of the cavity is intended for use primarily by aircraft service and flight personnel.

7.2 CABIN ENVIRONMENT

7.2.1 Cabin Temperature

Cabin temperature is maintained at $22^{\circ} \pm 2^{\circ}\text{C}$ during flight. Cabin temperature on the ground can be as high as 7°C above outside ambient temperature if the AIRO systems (compressors, console) are activated and ground air conditioning is not provided.

7.2.2 Cabin Humidity

Cabin humidity at observing altitudes (12 km or higher) generally averages less than five percent. Automatic hygrometers are provided to monitor cabin and cavity humidity and dewpoint.

7.2.3 Cabin Noise Level

Interference with non-amplified speech, possible auditory risk and potential adverse effects on experimental apparatus are acoustic noise problems arising from normal operation of the C-141 AIRO. Ear protection is provided for all in-flight personnel. The ICS headphones alone reduce the noise level substantially. Investigators should consider the effect of high noise levels on detectors, beam splitters, and other sensitive equipment. Future modifications are planned which will reduce acoustic noise to an 85 dbA level or less.

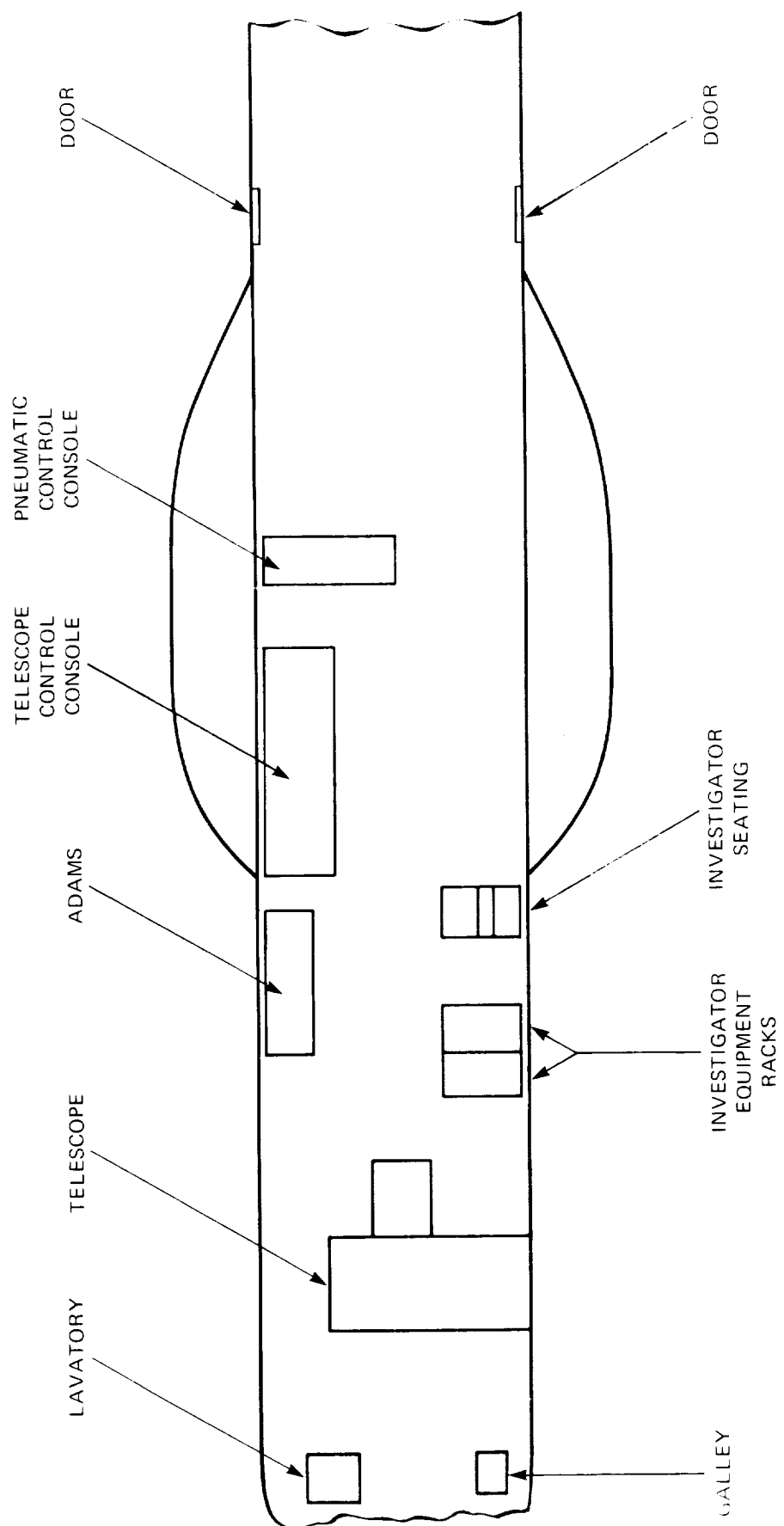


Figure I-15 Plan View of AIRO

7.2.4 Cabin Pressure Differential

A maximum cabin pressure differential of 430 mm Hg is automatically maintained. Table I-3 gives the nominal cabin pressure as a function of aircraft altitude. Cabin pressure differentials can be adjusted by the flight crew as necessary.

TABLE I - 3

CABIN PRESSURE VS. AIRCRAFT ALTITUDE

AIRCRAFT ALTITUDE (km)	AMBIENT PRESSURE (mm Hg)	CABIN PRESSURE (mm Hg)	PRESSURE DIFFERENTIAL (mm Hg)
0	760	760	0
2	600	600	0
4	463	567	104
6	355	567	212
8	260	567	307
10	193	567	374
12	145	567	422
14	108	538	430

7.2.5 Investigator Seating

Double-occupancy seats are provided for Investigators. In general, these seats are installed on the port side of the cabin, aft of the telescope, between FSN 664 and 759, along with the Investigator's equipment racks. Each seat requires 74 cm of fore-and-aft floor space. Minimum separation between seats, or between a seat and an Investigator's console, is 86 cm.

7.2.6 Galley and Lavatory

A hot food galley, refrigerator and coffee urn are located in the cabin on the port flight deck wall. Food and drink will be provided according to arrangements made prior to each flight.

A lavatory is located on the starboard side under the flight deck.

7.2.7 Safety Equipment

Life rafts, life vests, oxygen masks, fire extinguishers and other safety equipment are distributed throughout the cabin. Numerous emergency oxygen masks which deploy automatically are located along the cabin walls, starboard and port. Investigator personnel will be thoroughly indoctrinated in safety procedures and the locations of critical facilities prior to the actual mission.

8.0 IN-FLIGHT STANDARD OPERATING PROCEDURES

8.1 INVESTIGATOR-AIRCRAFT PERSONNEL INTERFACE GUIDELINES

To assure a smooth, efficient operation and preserve the safety aspects of high-altitude flight, it is important that Investigators be aware of duties of on-board ARC personnel, and the groundrules associated with flight crew interfaces. Normally, all communications from the Investigator will be directed to the Mission Director, who will contact other flight personnel as required.

8.2 INTERFACE WITH AIRCRAFT COMMANDER

During a flight, the Investigator should not require direct interface with the Aircraft Commander. If communications are required, they will be relayed via the Mission Director.

8.3 INTERFACE WITH CREW CHIEF

The Aircraft Crew Chief does not normally accompany scientific flights. Investigator/Crew Chief interface will more likely be required during installation and checkout of the Investigator equipment. All work associated with installation and operation of Investigator equipment while the aircraft is on the ground must be coordinated with the Crew Chief.

8.4 INTERFACE WITH SUPPORT SYSTEMS OPERATING PERSONNEL

Communications with the AIRO Systems Operators, the ADAMS Operator or other support systems personnel will be coordinated by the Mission Director whenever possible. Prior to flight, Investigators will be afforded ample opportunity to discuss with support systems operators tasks and in-flight schedules associated with their flights.

8.5 ALTERATION IN MISSION PROFILE

If it should become desirable during a flight to alter the previously-approved flight plan, the Investigator must request such deviation of the Mission Director, who will consult the Aircraft Commander. Final approval from the Aircraft Commander is required prior to initiation of flight plan changes.

8.6 EMERGENCY PROCEDURES

In the event of emergency, all on-board personnel will be guided by directions from the Aircraft Commander or the Mission Director.

9.0 OPERATIONS AND USE OF THE TELESCOPE BY INVESTIGATOR PERSONNEL

Except as approved by the Mission Director, the Investigator will not have access to direct telescope controls on the console. Remote controls, however, are available near the telescope for Investigator use in acquisition, tracking, and for focal plane monitoring. Selected telescope, environmental, and aircraft parameters are available for display on the console and can be communicated to the Investigator via the Mission Director.

ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH

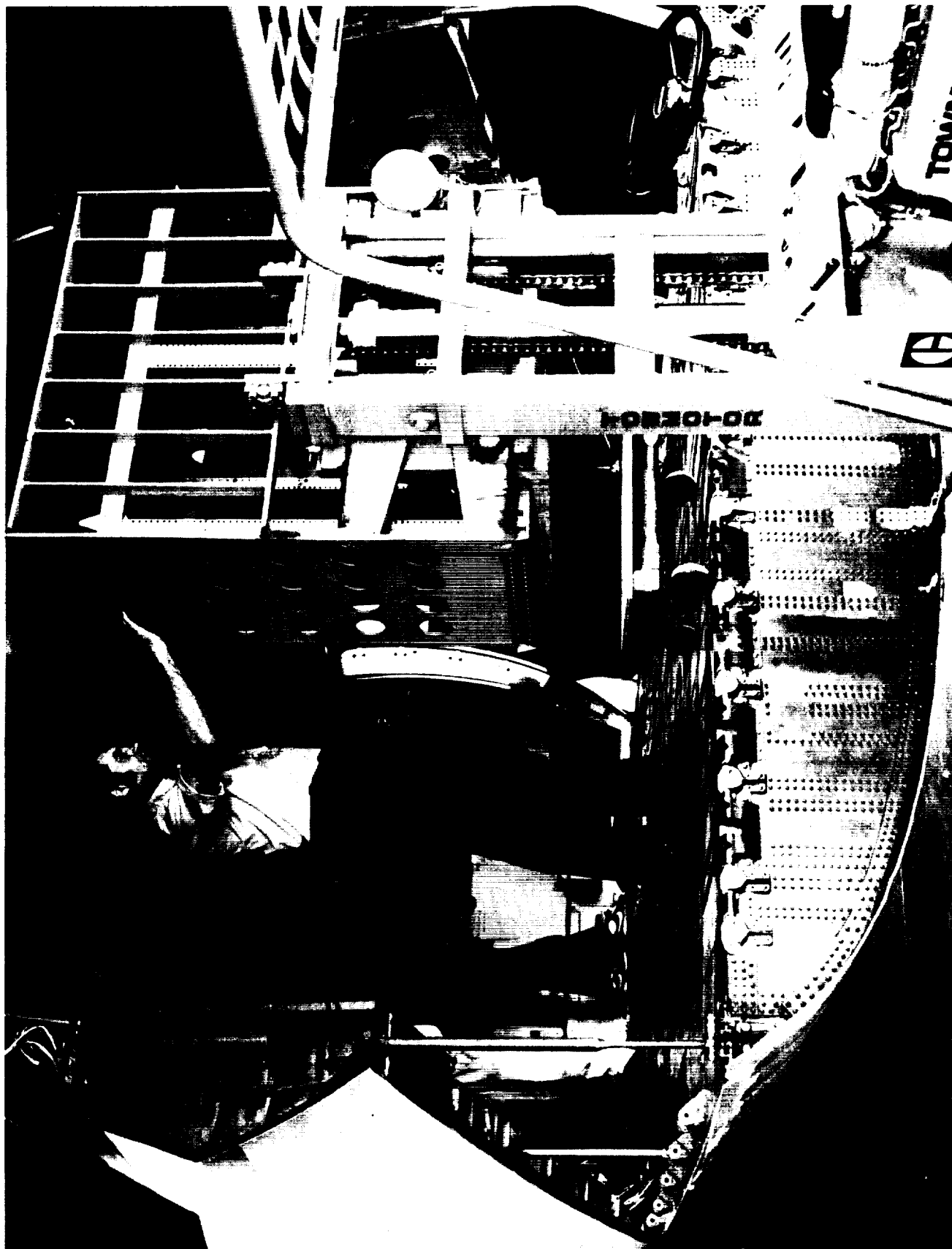
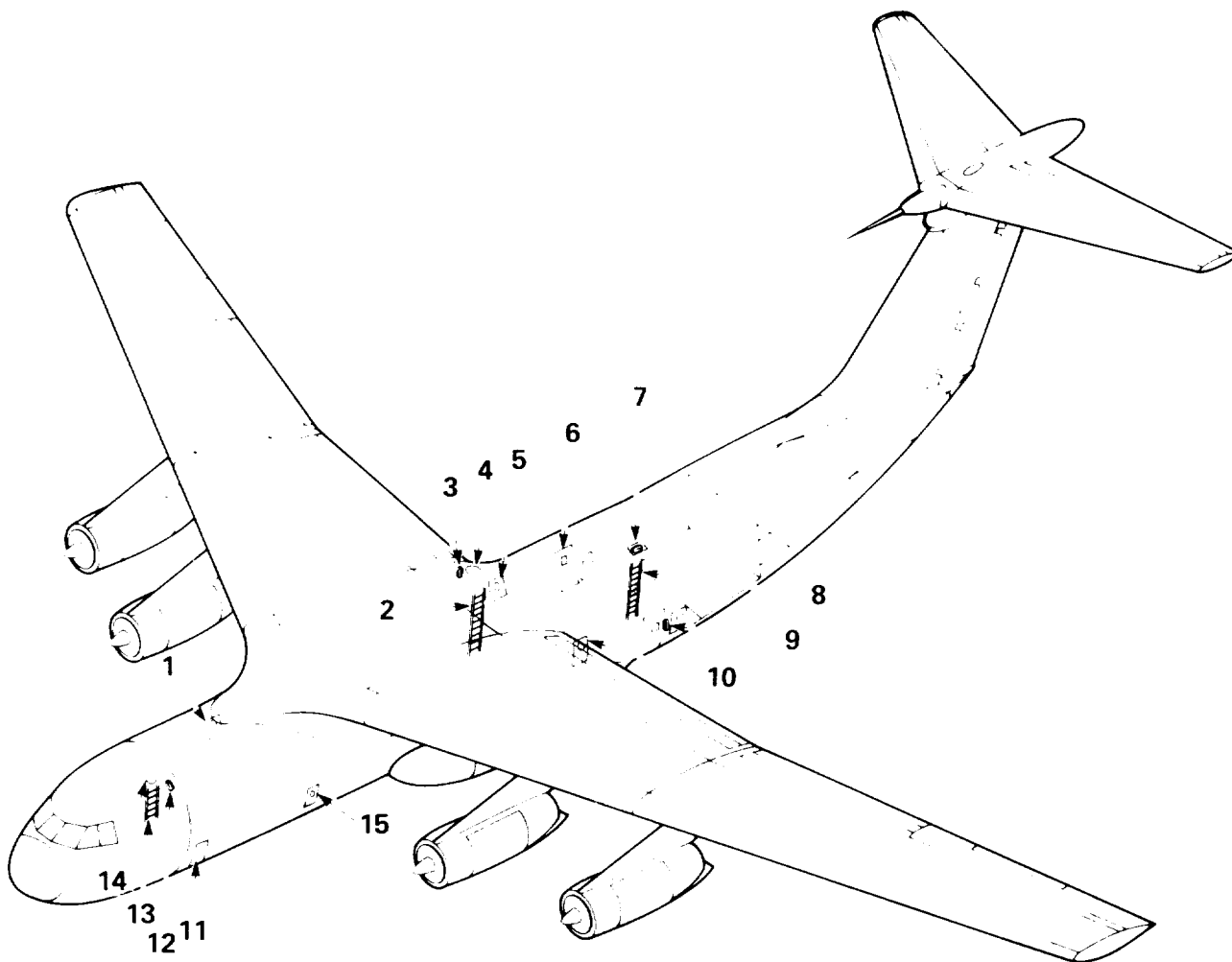


Figure I-16 Cargo Door and Ramp Area



- | | |
|---|---|
| 1. SIDE EMERGENCY EXIT DOOR (RH FORWARD) | 9. DOOR (LH REAR) |
| 2. EMERGENCY ESCAPE LADDER (RH REAR) | 10. SIDE EMERGENCY EXIT DOOR (LH REAR) |
| 3. ESCAPE ROPE (RH REAR EMERGENCY ESCAPE HATCH) | 11. CREW DOOR (LH FORWARD) |
| 4. EMERGENCY ESCAPE HATCH (NO. 3 HATCH) | 12. ESCAPE ROPE (FLIGHT STATION EMERGENCY ESCAPE HATCH) |
| 5. SIDE EMERGENCY EXIT DOOR (RH REAR) | 13. STATIONARY LADDER (FLIGHT STATION EMERGENCY ESCAPE HATCH) |
| 6. DOOR (RH REAR) | 14. FLIGHT STATION EMERGENCY ESCAPE HATCH (NO. 1 HATCH) |
| 7. EMERGENCY ESCAPE HATCH (NO. 4 HATCH) | 15. SIDE EMERGENCY EXIT DOOR (LH FORWARD) |
| 8. EMERGENCY ESCAPE LADDER (LH REAR) | |

Figure I-17 Location of Safety Equipment

C-141 AIRBORNE INFRARED OBSERVATORY

INVESTIGATOR'S HANDBOOK

S E C T I O N I I

INVESTIGATOR EQUIPMENT, DESIGN, DEVELOPMENT AND ASSEMBLY

1.0 COORDINATION AND PLANNING

In general, an Investigator's initial contact with the C-141 AIRO will be with the Project Manager. The Project Manager is responsible for overall scientific liaison with the Investigator and with the NASA Headquarters Program Office. He is also responsible for the overall management and operation of the observatory.

The C-141 AIRO Facility Manager is responsible for detailed planning and daily operation of the observatory.

Much of the Investigator's continuing liaison and requests for technical assistance will be channeled through the Facility Manager. ARC will furnish (at no cost) a nominal amount of technical help in the form of advice and installation manpower.

The names, addresses and functions of several AIRO staff members and other personnel who offer expertise in specific areas are listed in Table II-1. Investigators are encouraged to maintain close liaison with these individuals from the beginning of the program.

TABLE II - 1

INVESTIGATOR - ASO INTERACTION

PROJECT MANAGER <i>Robert M. Cameron</i> EXT. 5338 Science Operations Policy Grants Overall Planning	FACILITIES MANAGER <i>Carlton M. Gillespie, Jr.</i> EXT. 6302 Detailed Planning Logistics
<i>James O. McClenahan</i> EXT. 6484 Electronics Interface	<i>John W. Kroupa</i> EXT. 5345 <i>Robert B. Morrison</i> EXT. 5345 Overall Flight Planning
<i>Robert Munoz</i> EXT. 5343 ADAMS Interface	<i>F. C. Witteborn</i> EXT. 5523 NASA Observing Instruments (Mail Stop 245-6)
MAILING ADDRESS: Airborne Science Office (M.S. 211-12) Ames Research Center Moffett Field, California 94035	
TELEPHONE: (415) 965-XXXX (Direct dial extension)	

1.1 LEAD TIME

The lead time between the Investigator's program approval and first flight is, in general, on the order of 9 to 12 months. Shorter lead times may be practicable, depending upon the degree of complexity of the Investigator's program, and upon the circumstances and the event with which the Investigator is concerned.

A flow chart depicting an idealized operating plan for the C-141 AIRO is contained in Figure II-1. Although the time scales and action items shown on the chart are not mandatory, it is known that this plan generally produces more efficient operation. Investigators are strongly urged to organize their activities along the lines presented in the plan.

1.2 INVESTIGATOR'S PROGRAM QUESTIONNAIRE

The Investigator's Program Questionnaire should be completed and returned to the C-141 AIRO Project Manager as soon as practicable in the early planning stages of the Investigator's program (see Table II-2).

1.3 MISSION PROFILE PLANNING

As indicated in Figure II-1, at least two months prior to a planned observation, tentative flight profiles should be established. These should indicate geographical locations, altitudes and flight duration which are required or desirable. The flight profiles should be forwarded to Ames Research Center for review by the Project Manager (see Table II-1). Tentative approval or suggested modifications will be returned to the Investigator in sufficient time so that the final flight plan can be established no later than one week prior to the flight.

2.0 BASIC DESIGN DETERMINANTS FOR INVESTIGATOR INSTRUMENTS AND FLIGHT SUPPORT EQUIPMENT

Installation of the Investigator's equipment aboard the aircraft is very demanding and can be quite time consuming if adequate precautions are not strictly observed. In order to prevent a disappointing last minute cancellation of an Investigator's flight plans because of incompatibilities, this subsection describes the physical constraints and environmental factors necessary to allow sound equipment design.

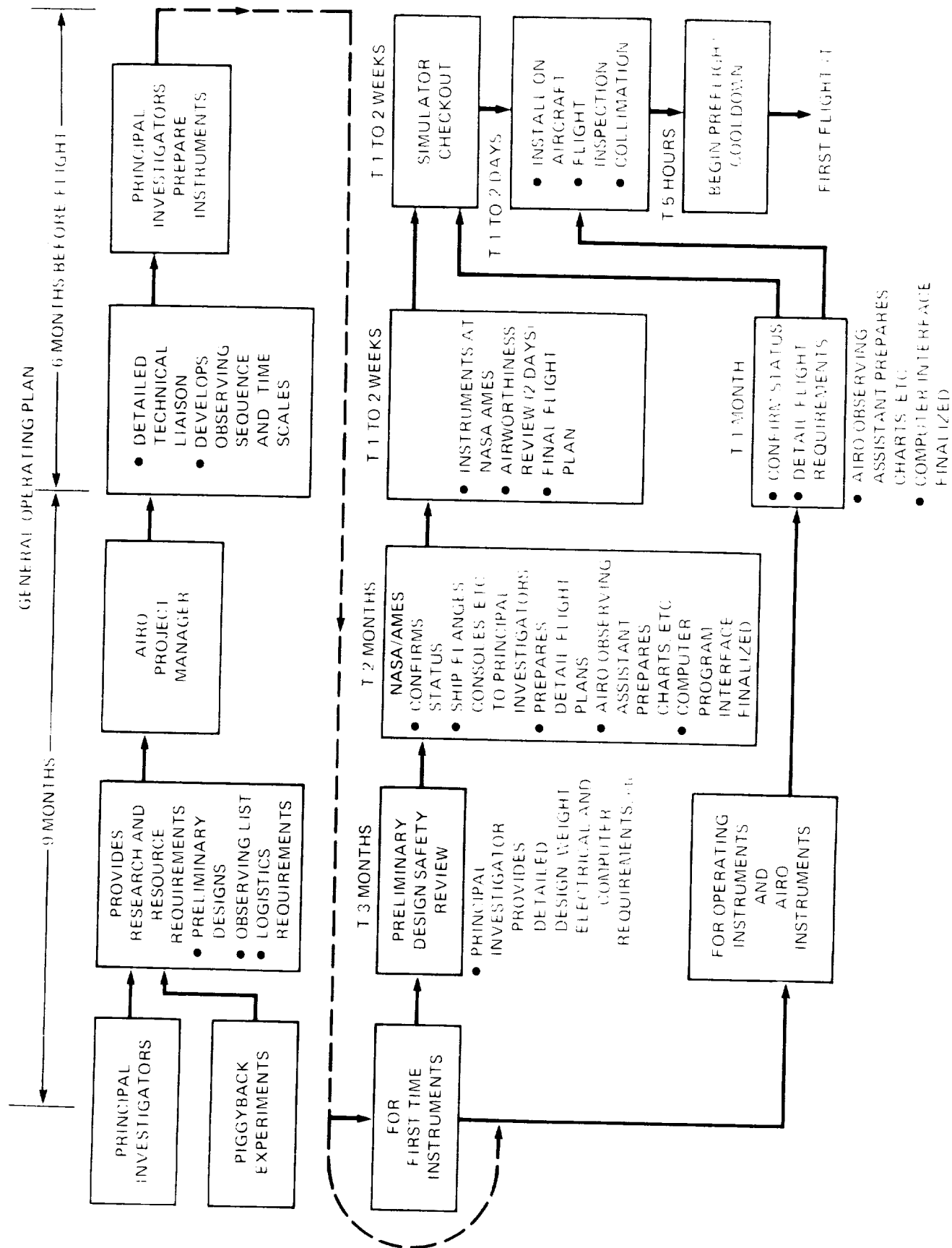


Figure 11-1 Airborne IR Observatory General Operating Plan

TABLE II - 2

INVESTIGATOR'S PROGRAM QUESTIONNAIRENames and Addresses of Participating Personnel

<u>NAME</u>	<u>ADDRESS</u>	<u>TELEPHONE</u>
_____	_____	_____
_____	_____	_____
_____	_____	_____

A. Summary of Specifications of Detector and Instrument

1. Type of Instrument: _____
(Interferometer, spectrometer, etc.)
2. Instrument Parameters:
 - a. Wavelength Range _____ microns
 - b. Resolution _____ wave numbers
 - c. Filter Passbands _____ microns
_____ microns _____ microns
3. Detector:
 - a. Type _____
 - b. Sensitivity _____
 - c. Noise Equivalent Power _____
4. Approximate Weight of Instrument: _____ kg
5. Telescope Focal Position Required: _____

(Normal Cass Focus, Bent Cass Focus & Flange Number, Pressure Environment)

TABLE II - 2 Continued

6. Telescope Back Focus Required: _____ cm
7. Vacuum Pumping Required:
 - a. Pressure _____ b. Flow _____
8. Type of Detector Cooling Employed and Approximate Amount of Cryogen Required per Day:

9. Oscillating Secondary Required?
 - a. Throw _____ b. Frequency _____
10. Raster Scanning Required?
 - a. Range _____ arc-min b. Rate _____ arc-second/second
 - c. Raster Step _____ arc-min

B. Electrical Requirements

1. General Description of Major Electronics Components:

	<u>Name</u>	<u>Manufacturer</u>	<u>Model No.</u>
a.	_____	_____	_____
b.	_____	_____	_____
c.	_____	_____	_____
d.	_____	_____	_____
e.	_____	_____	_____
f.	_____	_____	_____
g.	_____	_____	_____
h.	_____	_____	_____

TABLE II - 2 Continued

2. Peak Amount of 60 Hz 115 Vac Current Required: _____ amps

3. Peak Amount of 400 Hz 115 Vac Current Required: _____ amps

4. Description of Cabling Required:

a. From Detector to Investigator's Control Console

_____ (type and number of leads)

b. From Console or Detector to C-141 ADAMS

_____ (type and number of leads)

C. Object List

Proposed Observing Dates: _____

	<u>Object Name</u>	<u>Catalog Number</u>	<u>SAO Number</u>	<u>α(1950)</u>	<u>δ(1950)</u>	<u>m_v</u>
1.	_____	_____	_____	_____	_____	_____
2.	_____	_____	_____	_____	_____	_____
3.	_____	_____	_____	_____	_____	_____
4.	_____	_____	_____	_____	_____	_____
5.	_____	_____	_____	_____	_____	_____

2.1 ENVIRONMENTAL CONSIDERATIONS

The Investigator will find the following information on the environments of the cavity and the cabin of use in developing his instrument package, rack-mounted equipment, and other on-board equipment.

2.1.1 Uncontrolled Environments

All equipment including racks, instruments, pallets, tie-down bracketry, and carry-on items must be designed for the load conditions listed in Table II-3. These load conditions, when applied one at a time, must not produce a stress in any element of the equipment beyond the ultimate strength for the construction material.

The requirements in Table II-3 are for structural design of the equipment. It is not required that alignment, calibration, or other instrumental functions be maintained under these load conditions.

TABLE II - 3

MECHANICAL LOAD CONDITIONS

<u>Load Direction</u>	<u>Equipment-Load Factor</u>
Forward	9.0 g
Down	4.5 g
Up	2.0 g
Side	1.5 g
Aft	1.5 g

2.1.2 Controlled Environments

Dust, humidity, pressure, temperature, and vibration are controlled in both the cavity and the cabin for both the direct and bent Cassegrain modes of operation to the extent required. A slight positive pressure is maintained within the closed cavity to avoid ingestion of water vapor or dust from outside. While on the ground, a portable mechanical refrigerator is used to cool the cavity walls to the approximate predicted stagnation temperature at the observing altitude, and to trap any water vapor inside the cavity. In-flight cooling is provided by an on-board system.

The air bearing support effectively reduces rotational vibrations potentially transmitted from the airplane. Translatory vibrations are attenuated by an active isolation system. The isolators are designed with a high-frequency cutoff of 3 Hz. They support the telescope at four points forming a plane that contains the center of gravity of the telescope, thus eliminating cross coupling of linear vibrations. The telescope structure is designed for a natural frequency of greater than 35 Hz, while the air bearing has a natural frequency of greater than 150 Hz.

The cabin environment, which will affect the rack-mounted and other Investigator's support equipment, is described in subsection I-7.2, and is summarized in Table II-4.

TABLE II - 4
CABIN ENVIRONMENT

	MIN.	NOMINAL	MAX.
Pressure	108 mm Hg	567 mm Hg	760 mm Hg
Temperature	21°C	22°C	24°C
Vibration	TBD	TBD	TBD
Noise	---	TBD	108 db

2.1.3 Direct-Cassegrain Operation

In the direct-Cassegrain configuration, the optical pressure-window wheel must be turned to the open-port position to allow cables to go to the instrument package from the dome area either through the open port or via a feed-through plate installed in the open-port position. In the former case, this requires that the dome be in place, cooled, and evacuated to the cavity and outside conditions.

2.1.4 Bent-Cassegrain Operation

The telescope system may be operated with or without the instrument dome. With one of the pressure windows in the optical path (see Figure II-2), instruments can be operated in the cabin environment. With the pressure window wheel rotated to the open port position, the detector package can be operated in the cavity

ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH

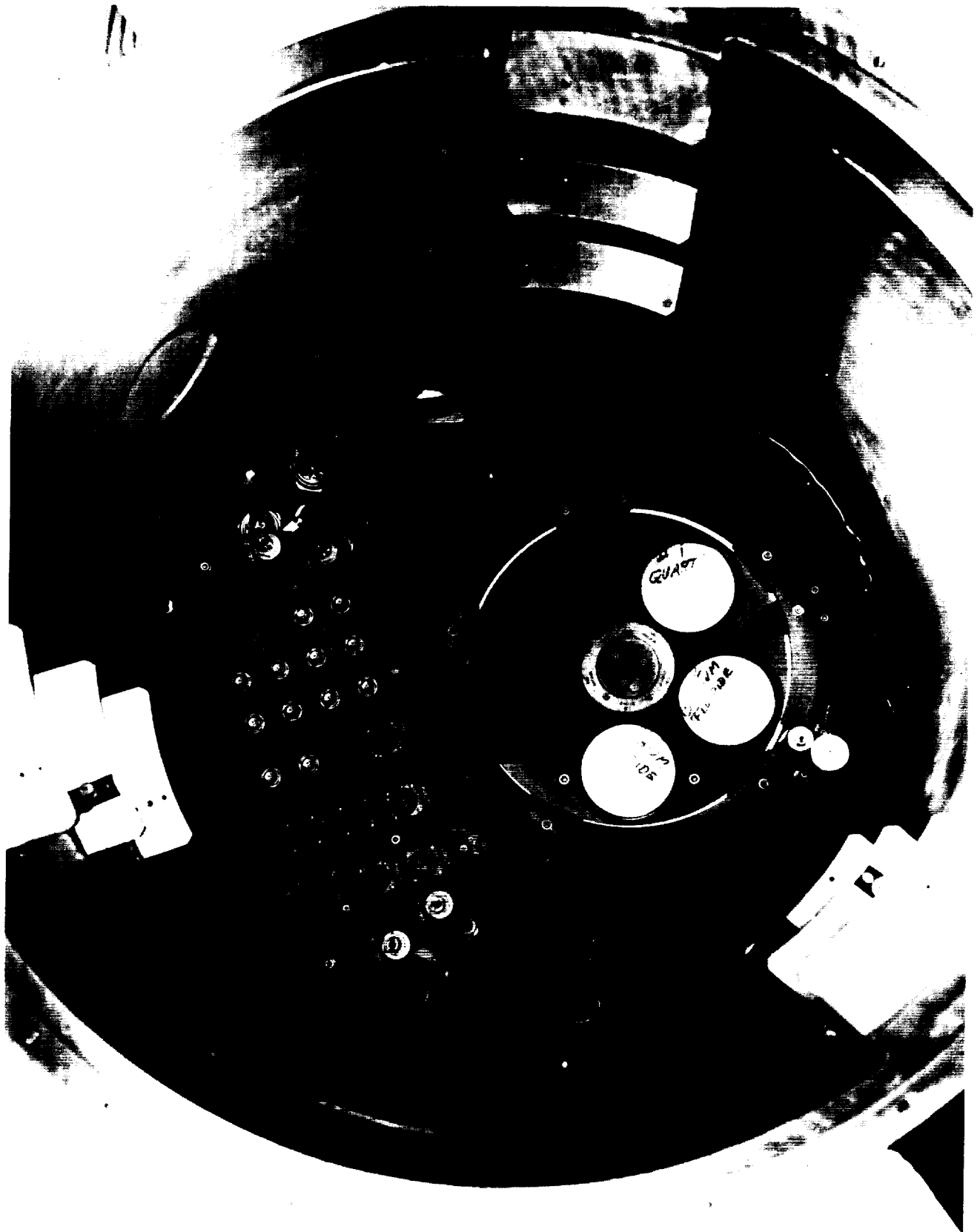


Figure II-2 Investigator's Interface Flange Section Connector Plate and Selector Wheel with Pressure Windows

environment, provided either (1) the pressure dome is installed around the detector package or (2) the Investigator's instrument mounting plate seals the instrument area. A failsafe interlock prevents rotating the pressure window wheel to the open port position when a pressure differential exists.

The instrument dome contains insulation and a liquid nitrogen cooling system to keep the interior of the dome walls at a low temperature. Investigator detector packages which are designed with their own cryogenic cooling systems can be accommodated. Dewars can be filled prior to take-off, but cryogen depletion must be taken into consideration as the dewars cannot be replenished during flight.

2.2 WEIGHT, DIMENSION, AND CENTER OF GRAVITY CONSTRAINTS

2.2.1 Direct-Cassegrain Instruments

The maximum allowable weight of the direct-Cassegrain instrument package is 45.4 kg. The maximum envelope dimensions are 29.0 cm diameter and 38.0 cm length, as shown in Figure II-3. The package is mounted on the adapter plate with the center of gravity 19.0 cm from the plate and on the mirror axis, as shown in Figures II-3 and II-4.

2.2.2 Bent-Cassegrain Instruments

The maximum allowable weight of the bent-Cassegrain instrument package is 159 kg. The maximum envelope dimensions are 60.0 cm diameter and 110.0 cm length as shown in Figure II-5. The package can be mounted on a mounting plate which can, in turn, be mounted on a set of mounting tabs or on the dome/flange interface. There are four levels of flange tabs available as shown in Figure II-5.

The maximum allowable moment is 178.08 kg-m, therefore a 159 kg instrument must not be more than 1.118 m from the centerline of the air bearing (0.305 m aft of the optimum focal plane flange, see Figure II-4). *Longer moment arms are acceptable if the weight of the instrument is reduced proportionally.*

2.2.3 Investigator's Equipment Rack

Investigators will be furnished standard racks designed for use in the C-141 aircraft, see Figures II-6, II-7, and II-8. The maximum weight of a loaded rack is 270.0 kg. The cg should be as low as practical, *with a maximum allowable overturning moment of 138 kg-m.* If the total overturning moment is kept below the 138 kg-m value, small items may be fastened to the top of the rack, see Section VII, "Loading Considerations for the NASA/Ames Double-Bay Equipment Rack for the C-141".

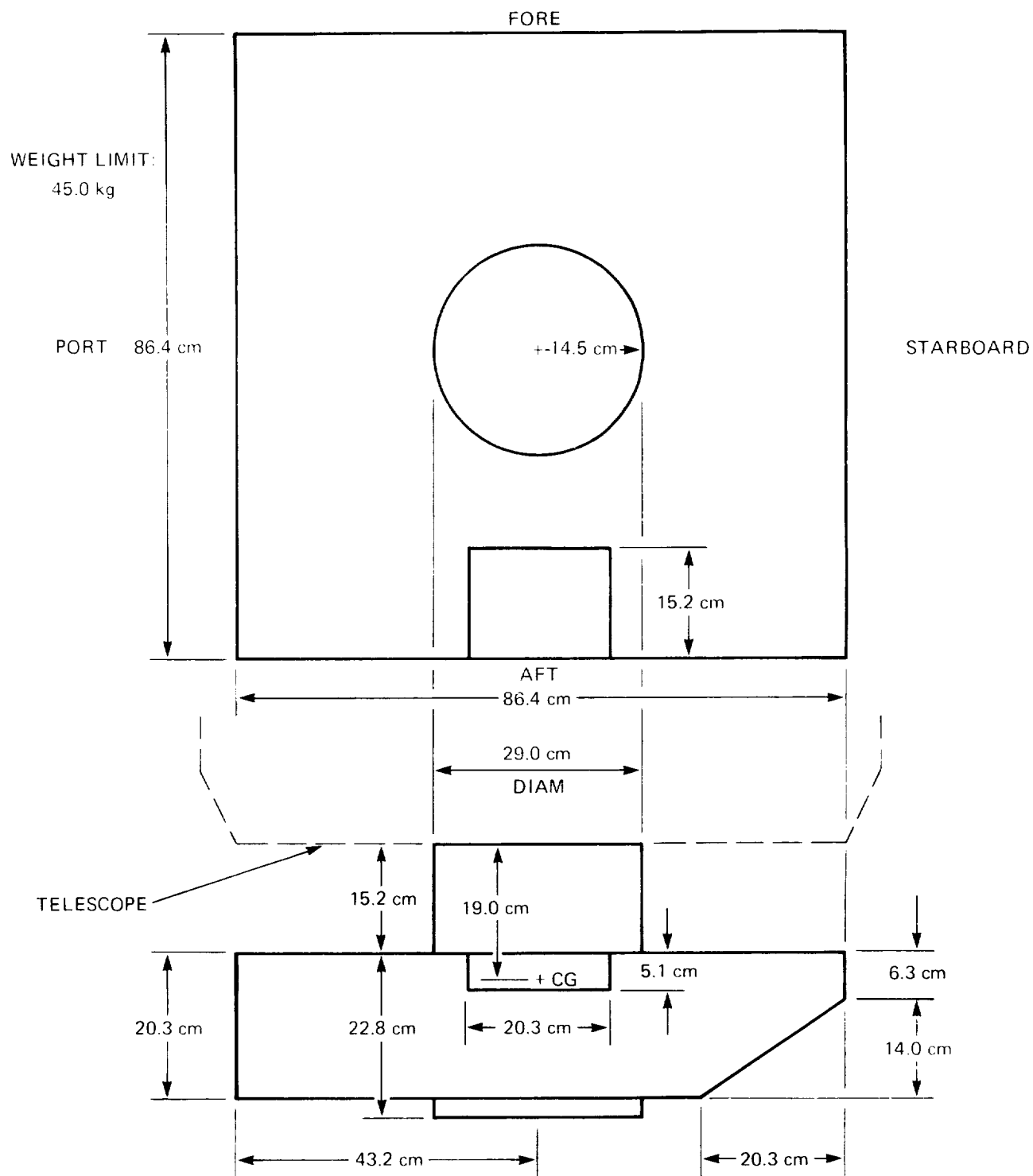


Figure II-3 Direct-Cassegrain Instrument Package Limits

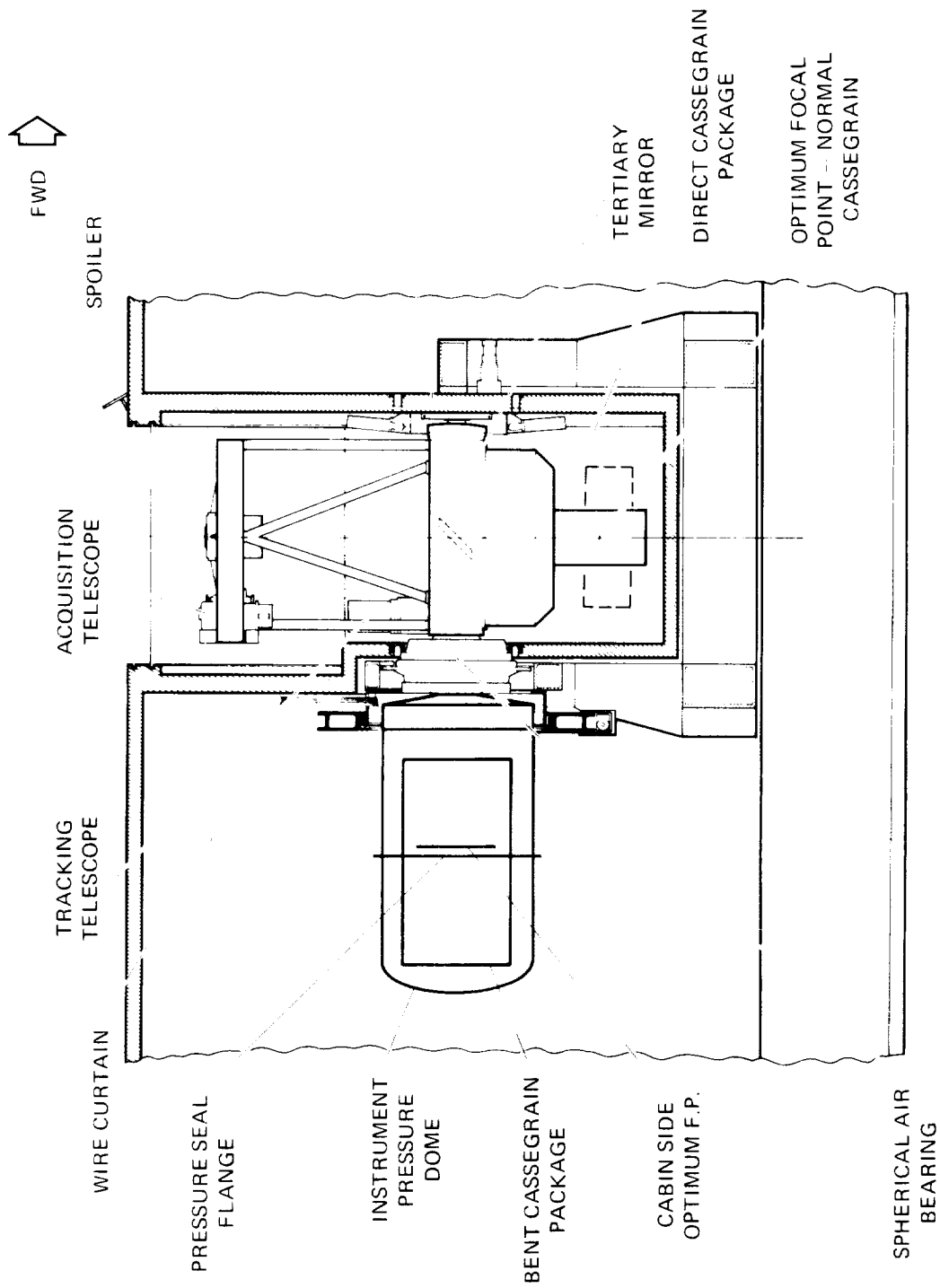


Figure II-4 Instrumentation Package Locations

BENT CASSEGRAIN INSTRUMENT PACKAGE LIMITS
MAXIMUM ENVELOPE DIMENSIONS
CENTER OF GRAVITY
WEIGHT LIMIT
REQUIREMENTS

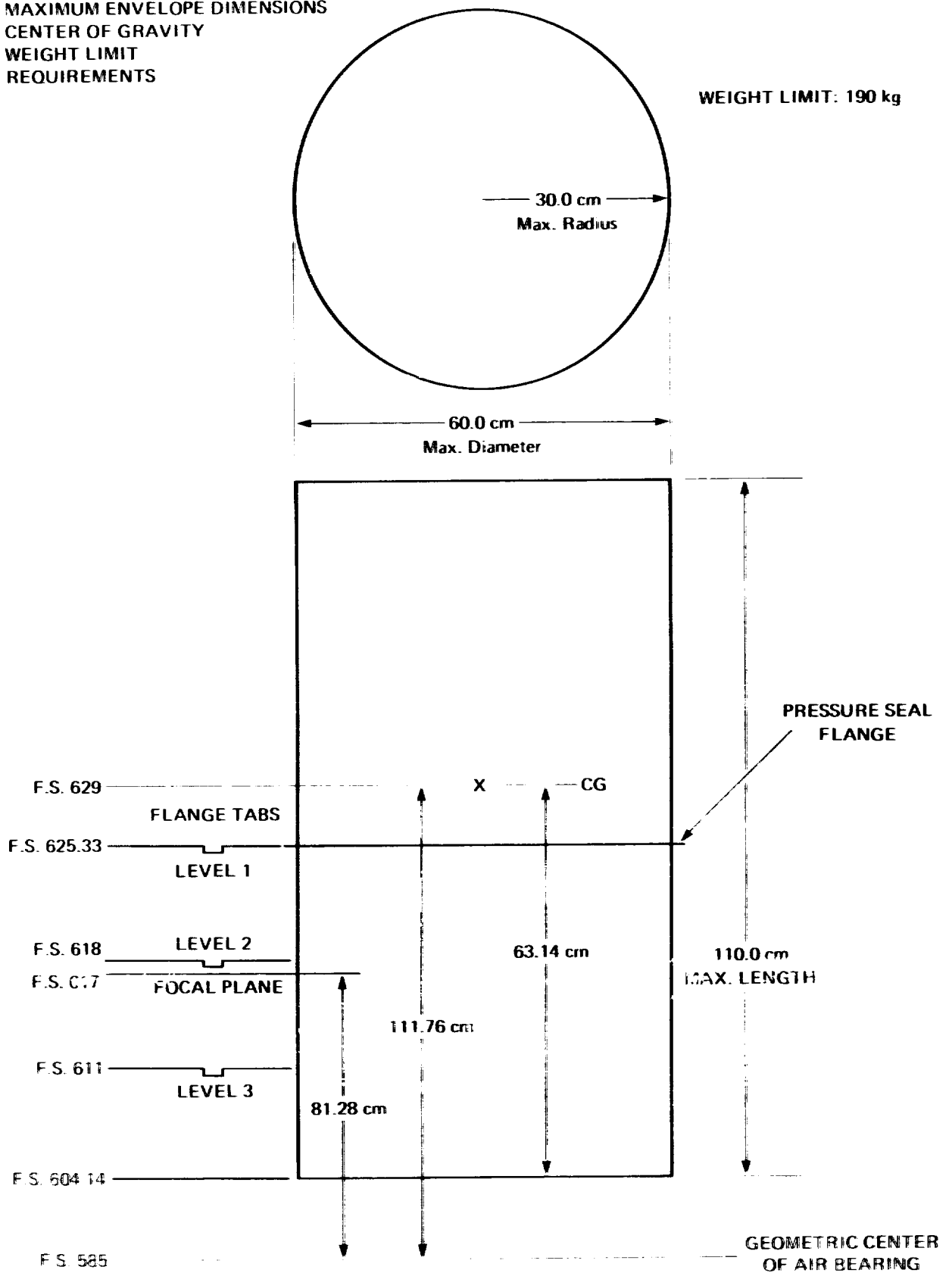


Figure II-5 Bent Cassegrain Instrument Package Limits

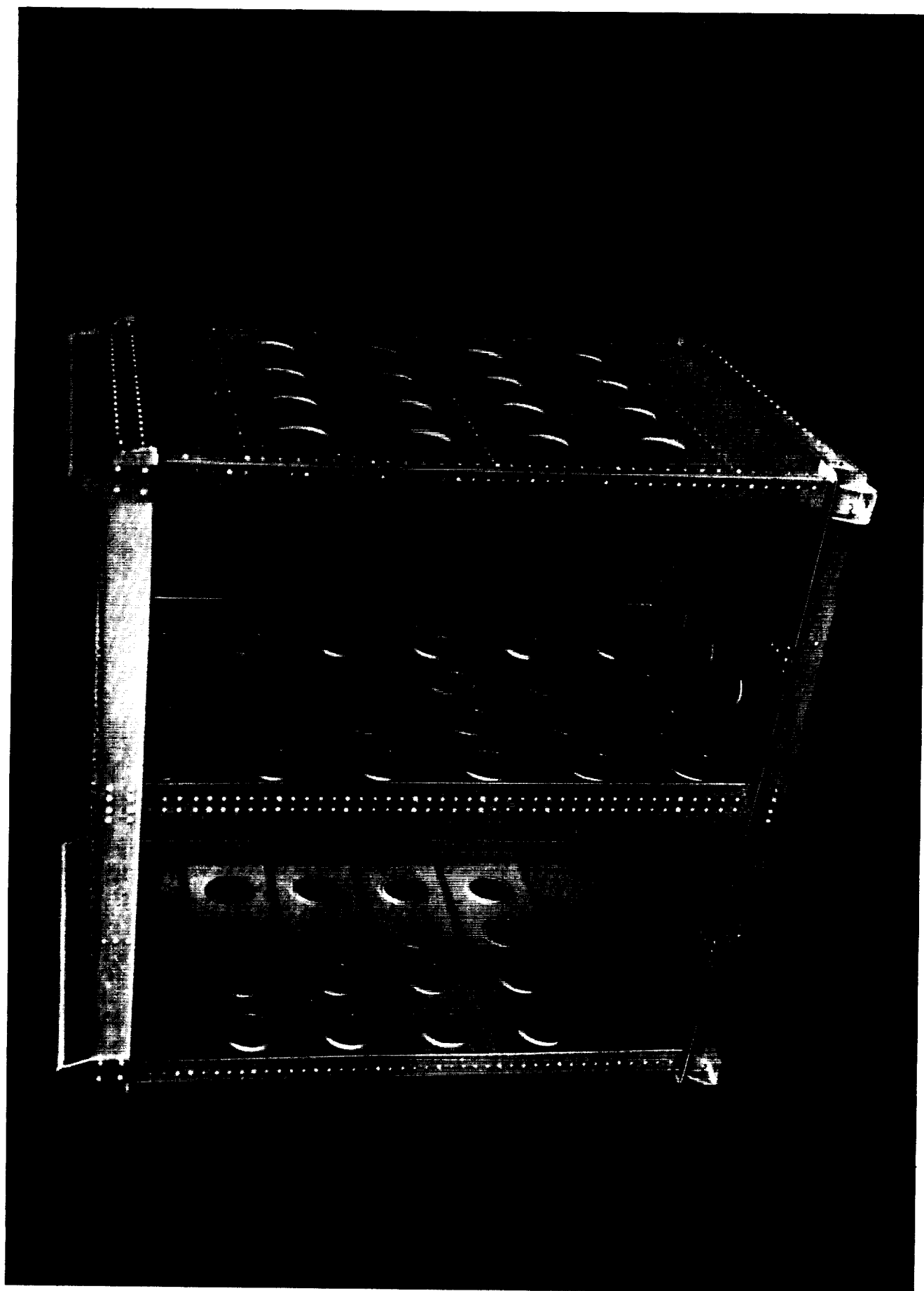


Figure 11-6 Investigator's Standard Double-Bay Rack

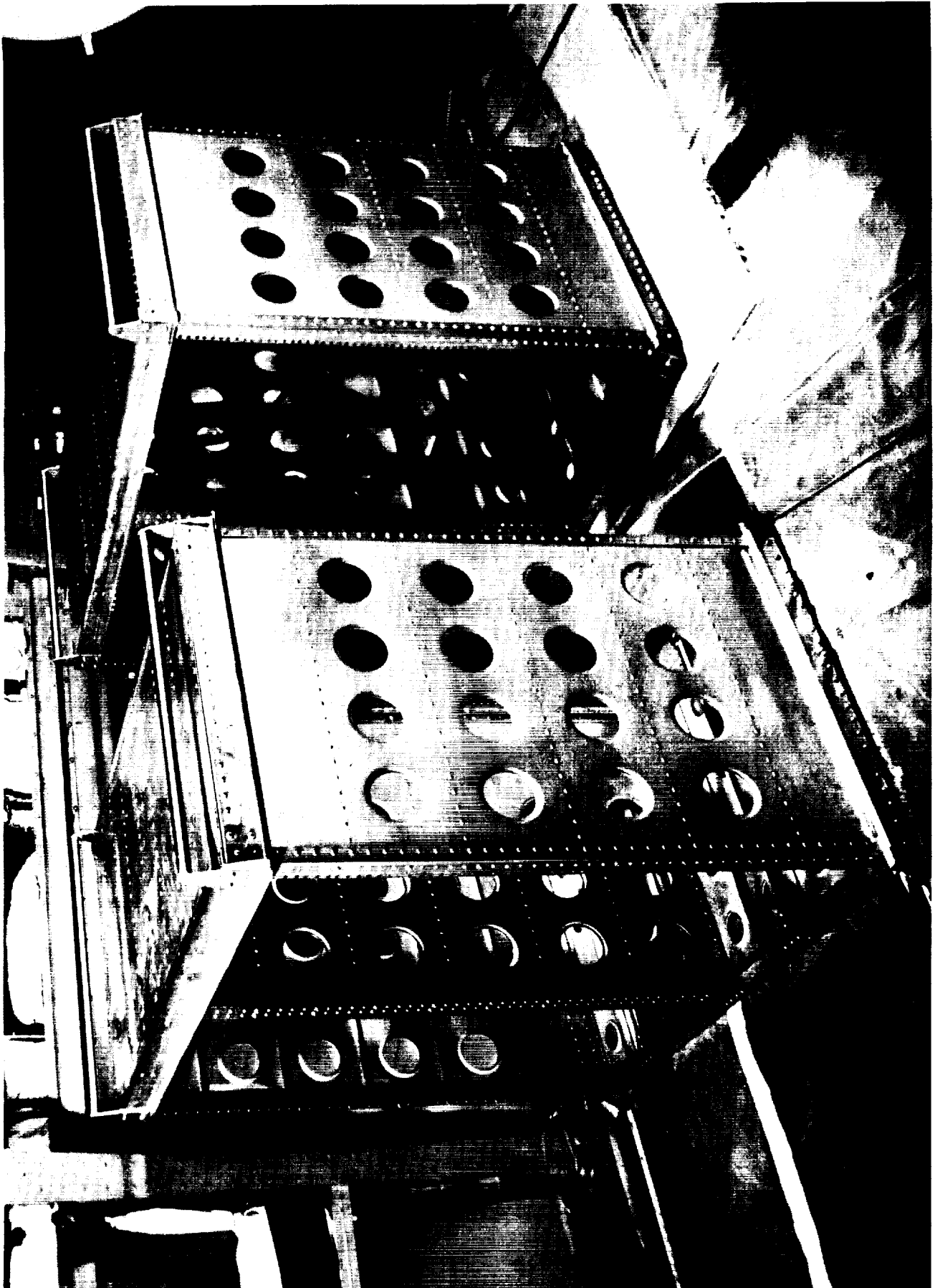


Figure II-7 Two Standard Racks

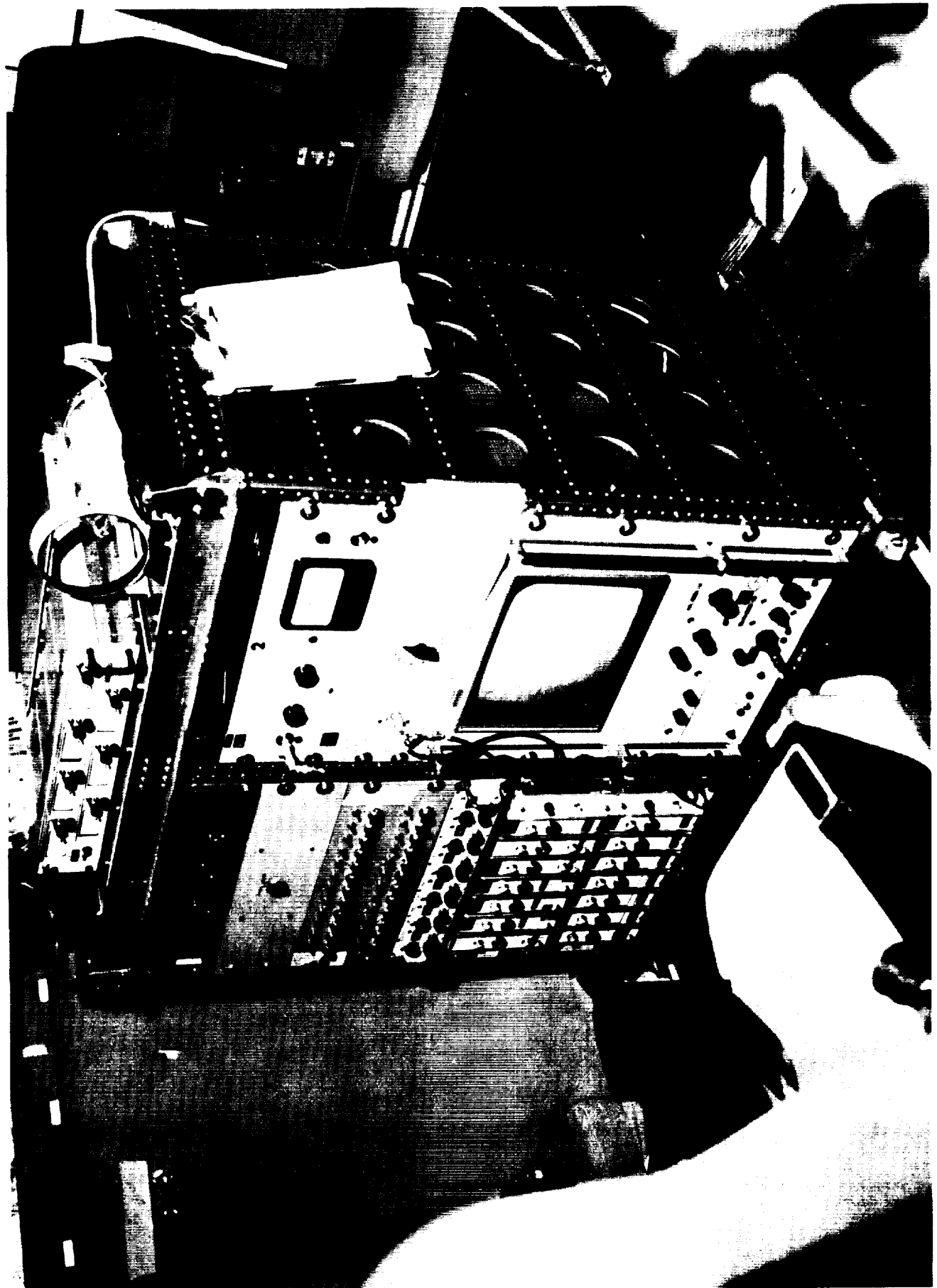


Figure II-8 Typical Rack-Mounted Equipment

2.2.4 Other Equipment

If the Investigator requires equipment not included in the instrument package or in the standard rack, he should communicate with the AIRO Facility Manager for specific instructions.

2.3 ELECTRICAL POWER AVAILABLE

The Investigator will have access to three primary sources of power while at Ames Research Center and aboard the aircraft: The AIRO Simulator, the Ground Power Unit (GPU) and Aircraft Power (A/C P). The characteristics of the 400 Hz and 60 Hz power available from these primary sources are given in Table II-5.

Aboard the aircraft, Investigators will be provided with one or more power distribution panels which interface between the aircraft electrical power and the Investigator's equipment rack. These panels are located on or near the rack and contain sufficient outlets for connection of 60 Hz and 400 Hz power (see Figure II-9). Both of these power sources are single phase and are terminated in three contact UL-type receptacles. Caution should be observed to prevent damage to frequency sensitive equipment. Multiphase 400 Hz power is available through four contact MS-type connectors of the type shown in Figure II-9.

2.3.1 Simulator Power

The simulator power will help the Investigator to ascertain his instrument's compatibility with the aircraft. Some characteristics are given in Table II-5. The balance will be included in a later edition of this handbook.

2.3.2 Ground Power Unit (GPU)

All power requirements in the aircraft are supplied by the GPU until all four engines are running. GPU power characteristics are given in Table II-5.

2.3.3 Aircraft Power (A/C P)

Characteristics of aircraft 400 Hz and 60 Hz are given in Table II-5. Switchover from GPU to A/C P is accomplished with a power contactor which has a transition time of approximately 50 ms. This time delay has a momentary effect of slightly decreasing the 60-Hz system voltage.

TABLE II-5
CHARACTERISTICS OF ELECTRICAL POWER SOURCES
FOR INVESTIGATOR EQUIPMENT

POWER SOURCE	CONFIGURATION	POWER AVAILABLE	LOAD REGULATION	WAVEFORM DISTORTION	FREQUENCY REGULATION
AIRO Simulator	400 Hz, 115 V 1 ϕ , 3 Wire	2 kVA	± 3.5 V	5.0% Max	± 4.0 Hz
	400 Hz, 208 VL-L 115 V L-N	TBD	TBD	TBD	TBD
	60 Hz, 208 V 1 ϕ , 3 Wire	As Needed	$\pm 5.0\%$	TBD	TBD
On Board Aircraft A/C Power	400 Hz, 115 V 3 ϕ , 4 Wire	3 kVA Max	TBD	TBD	TBD
	400 Hz, 115 V 1 ϕ , 2 Wire		TBD	TBD	TBD
	60 Hz, 115 V 1 ϕ , 2 Wire	4 kVA Max	± 3 V, No Load To Full Load	5.0% Max	$\pm 1.0\%$
On Board Aircraft GPU Power	400 Hz, 115 V 3 ϕ , 4 Wire	TBD	$\pm 1.0\%$	2.0% Max	± 1.0 Hz
	400 Hz, 115 V 1 ϕ , 2 Wire		$\pm 1.0\%$	2.0% Max	± 1.0 Hz
	60 Hz, 115 V 1 ϕ , 2 Wire	4 kVA Max	± 3 V, No Load To Full Load	5.0% Max	$\pm 1.0\%$

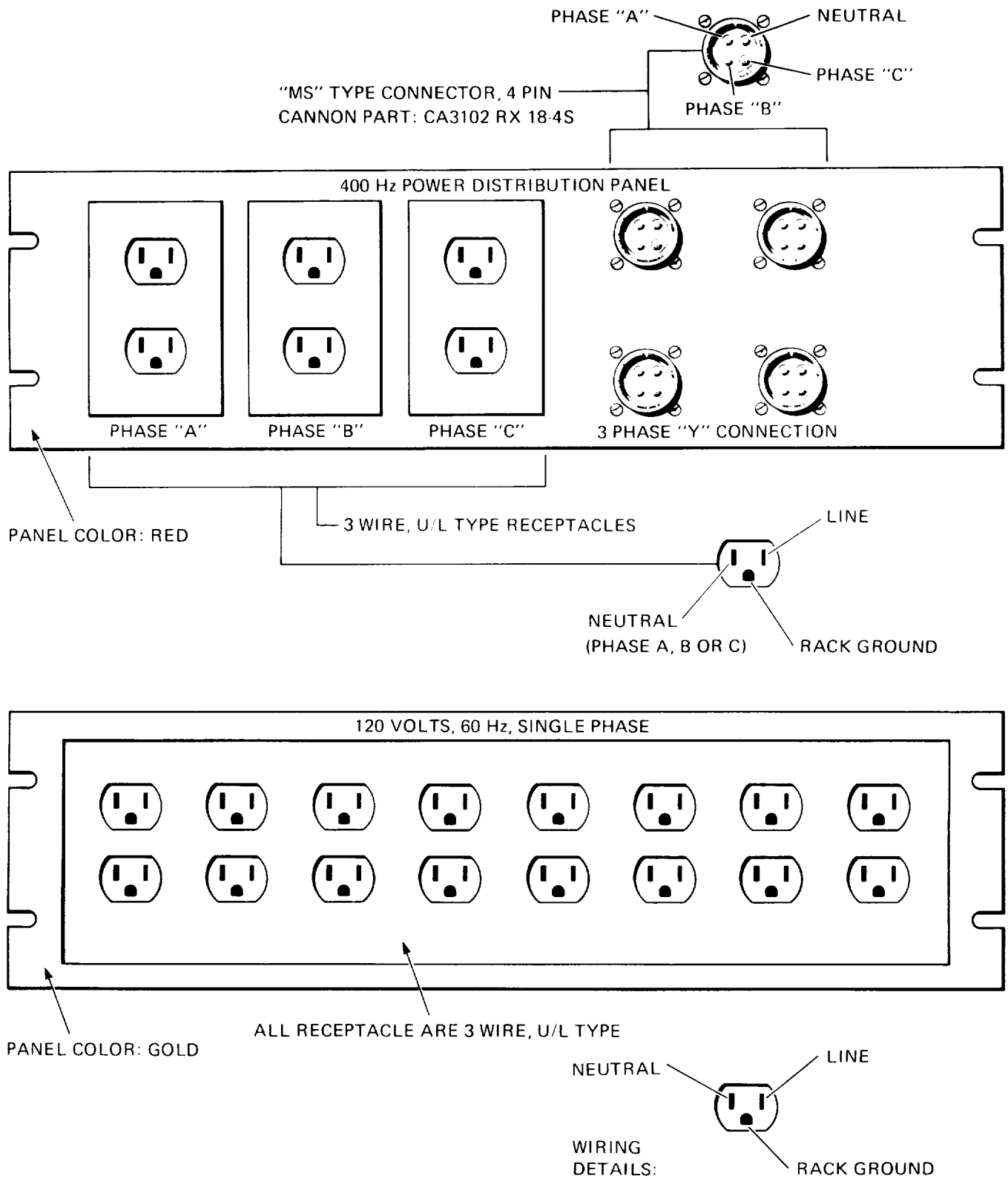


Figure II-9 Investigator's Equipment Rack Power Distribution Panels

Short circuit protection is accomplished by an electronic circuit which has a very short response time. Therefore, caution should be exercised in the use of motors or other loads which exhibit high starting surges. Overload protection is provided by means of an input circuit breaker whose rating, relative to output power, is slightly greater than the 8 KVA rating of the device. Therefore, caution should be exercised in loading so that a condition may not exist which would damage the unit.

No dc is available. Direct current power required by the Investigator must be derived from dry cell-type batteries furnished by him, or converted from 400 Hz by his equipment. For safety reasons, no acid-type batteries are permitted on board the aircraft.

2.4 AIRWORTHINESS AND SAFETY CONSIDERATIONS

It is possible that certain areas of design normally acceptable for ground-operated equipment can cause hazardous conditions aboard a jet aircraft flying to high altitude. The following items are covered briefly as reminders of the necessity to maintain a high level of safety aboard the aircraft.

2.4.1 Material Stability

Several factors should be considered by the designer before selecting materials for a specific function. They must not be capable of supporting combustion, and should of course be stable at expected operating temperatures. Tests show that certain insulating and impregnating materials used in the manufacture of inductive components (transformers, chokes, etc.) can liberate explosive gases when the component is operated at elevated temperatures. Some materials outgas at low pressures (nominal cabin pressure equivalent to an altitude of 3.35 km - minimum equivalent to 4.27 km). Select or design only those components which will not be physically or functionally degraded by cabin environment (see Section II-2.1).

2.4.2 Electrical Considerations

If necessary, hermetic sealing and pressurization may be employed to preclude corona, electrical arcing, or damage at reduced atmospheric pressure. The following objectives should be considered in design and layout of cables:

- a. Prevent physical interference with other systems
- b. Prevent coupling interference between systems or equipment
- c. Provide access for maintenance
- d. Minimize possibility of damage during normal and abnormal use
- e. Provide abrasion resistance
- f. Provide design for maximum reliability
- g. Provide for sufficient stress relief of cables and connectors

Signal and power leads should be physically separated to prevent coupling, and signal leads should be shielded where practical. Wire types and sizes should be selected for compatibility with anticipated voltages and currents. Well-controlled soldering and workmanship procedures and practices will contribute significantly to the reduction of equipment failures. (See Section II-8.0, and Section VII, Ref. D)

2.4.3 Human Engineering

Investigator's equipment must be designed for non-hazardous normal and emergency operation. Connectors should be clearly identified. All indicators used for monitoring adjustments should be placed so that they are readily observed during the adjustments. Fuses and circuit breakers should be readily accessible without removing other components. All terminals having potentials exceeding 50 V shall be insulated to prevent accidental human contact.

2.4.4 Equipment Effects

The operation of the Investigator's equipment must not degrade the cabin environment by emitting noxious fumes, inducing mechanical vibration, emitting electrical sparks, EMI/RFI, etc. Some temperature increase in Investigator rack-mounted equipment is expected, but the amount should be reasonable. Similarly, normal boil-off of cryogen gases such as liquid nitrogen, helium or neon used in research dewars is acceptable.

The frequency ranges of the various radio equipment are listed in Table II-6. Investigators are advised to engineer their equipment to prevent spurious response at these frequencies and to limit any output from their systems (e.g., telemetry) to the lowest practical level, generally less than 100 milliwatts. Excessive interference must be reduced to acceptable levels and demonstrated for compliance before the equipment can be used on the aircraft.

TABLE II - 6

RESTRICTED FREQUENCIES

Low Frequency	190 to 1750 kHz
Loran A	1.8 to 2.0 MHz
High Frequency	2.0 to 30 MHz
Marker Beacon	75 MHz
Very High Frequency	108 to 150 MHz
Ultra High Frequency	225 to 400 MHz
Tacan	960 to 1215 MHz
Radio Altimeter	4200 to 4400 MHz
Doppler Radar	8800 MHz
Weather Radar	9375 MHz

2.4.5 Small Equipment Stowage

All items, regardless of size, must be secured during takeoff and landing. While airborne, it is permissible to relocate items which are soft (or which can be made soft by padding) and which weigh less than 4.5 kg. However, because of frequent gust loads, these items must again be secured after relocation. *Personal briefcases, cameras, binoculars, etc., are definitely included in this requirement.*

2.4.6 Film Processing

Film processing (other than Polaroid-type) is not permitted on the aircraft because of danger from spilled chemicals.

3.0 DIRECT-CASSEGRAIN MOUNTING

The direct-Cassegrain instrument package is attached to the base of the telescope and operates in the cavity environment, which is normally exposed to the outside atmosphere. At the present time there is no convenient method for visually monitoring the package during flight. Thus, Investigators should incorporate this feature into the design of their instrument, if electro-optical monitoring is required.

3.1 DEMONSTRATED PERFORMANCE AT REDUCED ATMOSPHERIC PRESSURE

Since the low-pressure flight environment imposes specific severe requirements on the instrument package design, a series of three sequential tests may be performed to demonstrate capability of the package to perform satisfactorily in the expected flight environment. First, the package should be tested in reduced pressure environment at the Investigator's facility. If this is not possible, he may test the package at the ARC laboratory. Second, if the Investigator tests his package at his facility, he may recheck it at the ARC lab when he is ready to install it for flight. Third, prior to actual flight, it may be checked in the Ames AIRO Simulator.

3.2 COMPATIBILITY WITH INSTRUMENT INTERFACING DRAWING

The package should match the telescope interface (see Figures II-10 and II-11).

3.3 CONNECTION OF INSTRUMENT TO POWER, SIGNAL, AND HELIUM PUMPING LINES - (DIRECT CASSEGRAIN)

Figure II-12 is a sketch representing the cable routing between the various hardware items and the appropriate interfaces. The lines from the instrument package will go through either the open port in the pressure-window wheel or a special bulkhead feedthrough to the flange section connector plate shown in Figures II-13 and II-2. Some or all of the following connectors will be needed by the Investigator's equipment to mate with the plate connectors, depending on the complexity of the package. (Contact the AIRO Facility Manager if difficulty is encountered in obtaining these connectors):

a. ITT Cannon-type circular connectors required:

U7P64	MS 3106A16-10P (A95)
U7P65	MS 3106E16-10PW (A95)
U7P66	MS 3106E16-10PX (A95)
U7P67	MS 3106E16S-5P (A95)
U7P68	MS 3106E16S-5PW (A95)
U7P69	MS 3106E16S-5PX (A95)

Cable clamp included in above number.

b. High voltage connectors to mate with Rowe cable assembly:

U7P70	#6RC1135 Rowe Industries - with cable clamp
U7P71	#6RC1135 Rowe Industries - with cable clamp

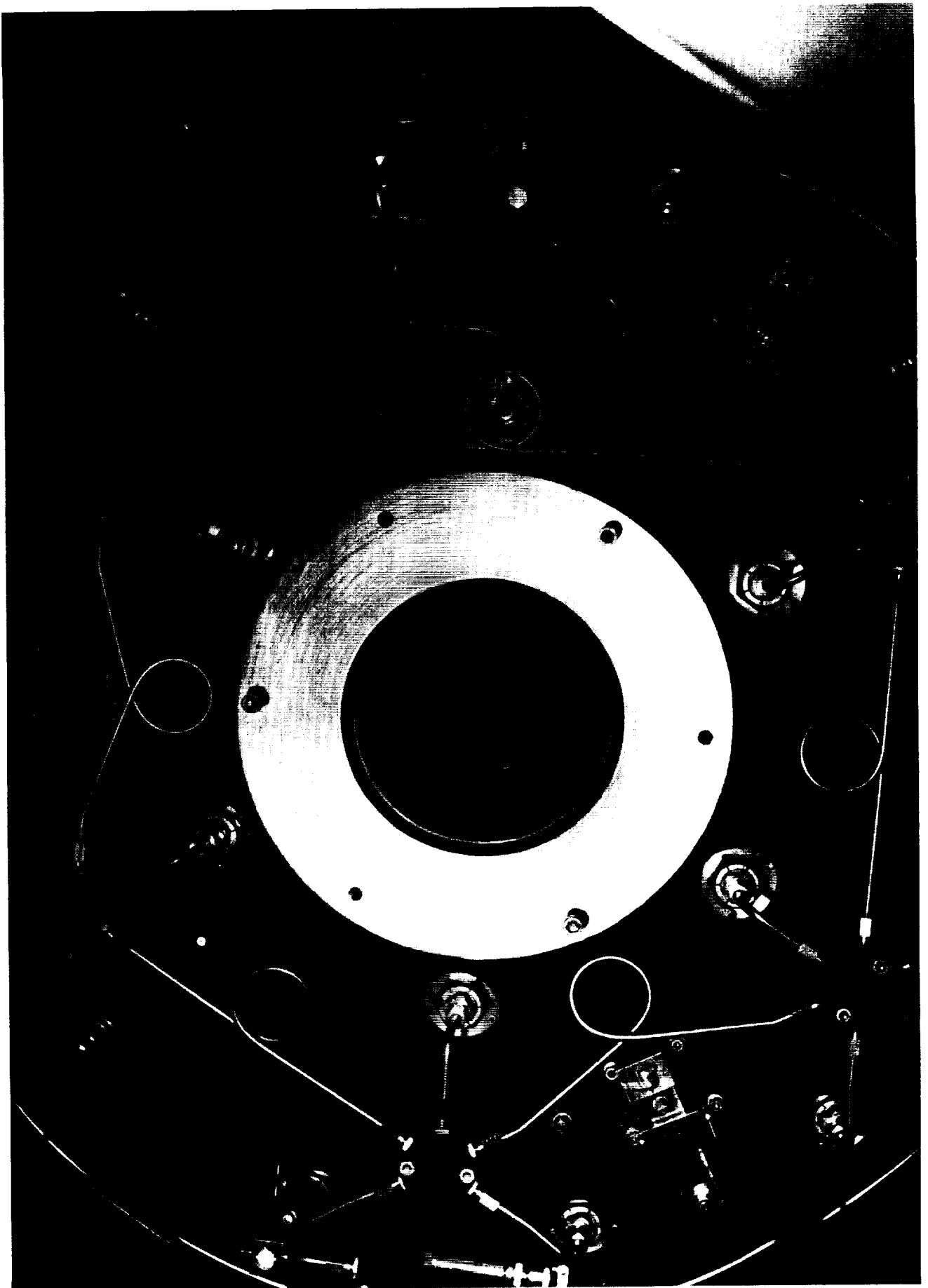


Figure II-10 Base of Telescope

WEIGHT LIMIT: 45.0 kg

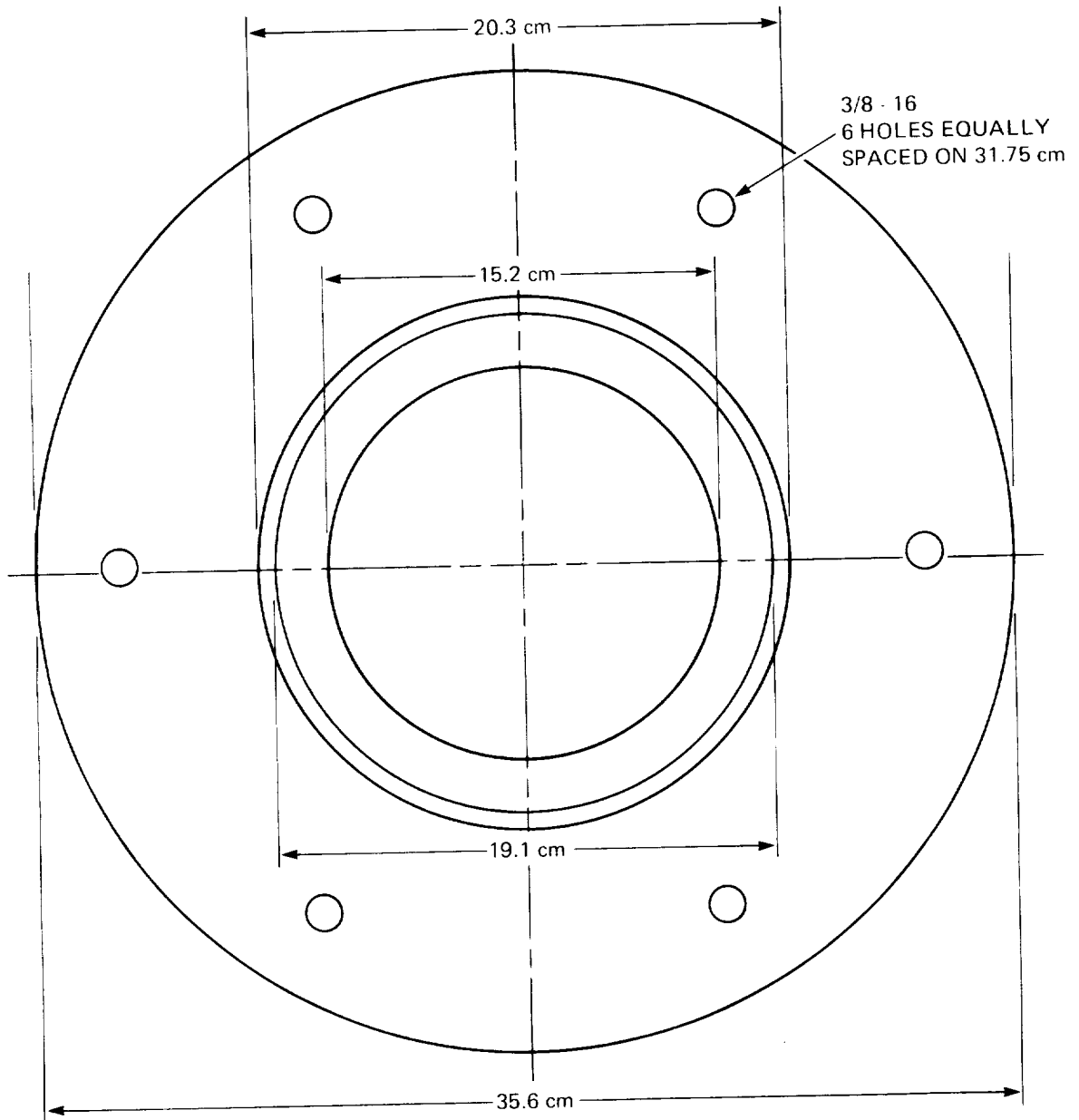


Figure II-11 Direct Cassegrain Instrument Interface

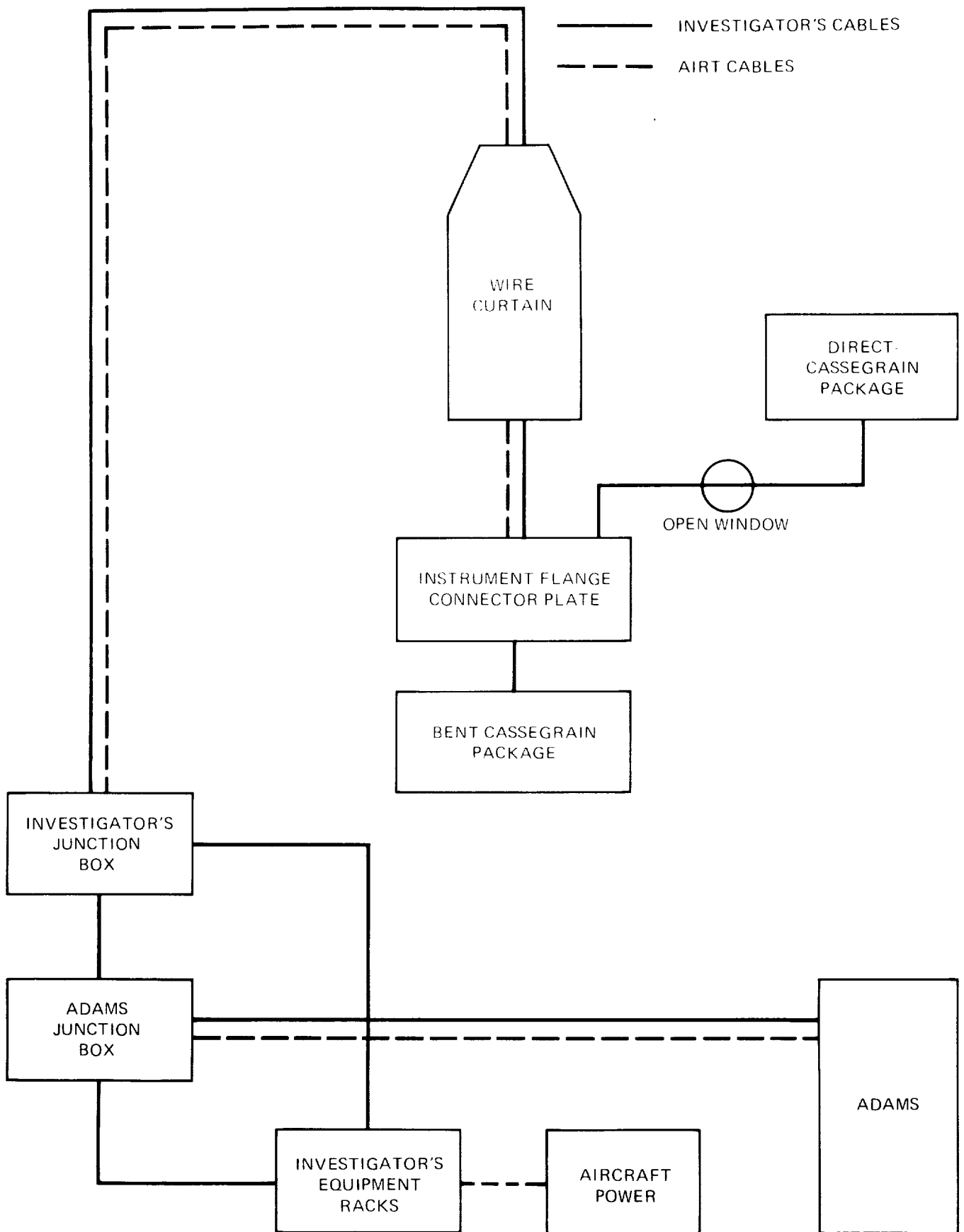


Figure II-12 Investigator's Cable Routing

c. Coax connectors to mate with ITT Gremar bulkhead connectors:

U7P72 to U7P83 #6955 ITT Gremar Connector

d. Vacuum hose fittings:

Four lines terminated with MS 33515S6 end fitting

The Investigator should furnish the AIRO Facility Manager with desired pin and connector power and signal assignments. If any particular keyway orientations are desirable, such requirements should also be transmitted to the Facility Manager.

4.0 BENT-CASSEGRAIN MOUNTING

In the bent-Cassegrain mode, the instrument package is mounted on a special mounting plate. This plate should hold the package so that the detector can be at or near the focal plane formed after the beam has been reflected by the tertiary mirror. The optical and Vidicon monitoring facilities will be available as described in Section I.

4.1 DEMONSTRATED PERFORMANCE AT REDUCED ATMOSPHERIC PRESSURE

If desired by the Investigator, a series of three sequential tests (similar to those in subsection II-3.1) can be performed to show the capability of the instrument package to perform in a reduced pressure environment. First, if environmental testing equipment is available, the package should be tested at the Investigator's facility under a partial vacuum of 100 mm/Hg or less. If this is not feasible, the package can be tested at the Ames laboratory. Second, the package may be rechecked at the ARC lab when ready to it. Third, prior to flight, it may be checked in the Ames AIRO Simulator.

4.2 COMPATIBILITY WITH INSTRUMENT INTERFACING DRAWING

Each Investigator working at the bent-Cassegrain position will be furnished with a special plate to interface his package with the bent-Cassegrain flange or tabs.

4.3 CONNECTION OF INSTRUMENT TO POWER, SIGNAL, AND HELIUM PUMPING LINES - (BENT-CASSEGRAIN)

For a visual understanding of the signal and power lead routing see the block diagram, Figure II-12. The lines can go directly from the instrument package (if inside the dome or flange section) to the flange connector mounting plate shown in Figures II-13 and II-2. Some or all of the following connectors will be needed by the Investigator's equipment to mate with the plate connectors depending on the complexity of the package. (Contact the AIRO Facility Manager if difficulty is encountered in obtaining these connectors):

a. ITT Cannon-type circular connectors required:

U7P64	MS 3106A16-10P (A95)
U7P65	MS 3106E16-10PW (A95)
U7P66	MS 3106E16-10PX (A95)
U7P67	MS 3106E16S-5P (A95)
U7P68	MS 3106E16S-5PW (A95)
U7P69	MS 3106E16S-5PX (A95)

Cable clamp included in above number.

b. High voltage connectors to mate with Rowe cable assembly:

U7P70 #6RC1135 Rowe Industries - with cable clamp
U7P71 #6RC1135 Rowe Industries - with cable clamp

c. Coax connectors to mate with ITT Gremar bulkhead connectors:

U7P72 to U7P83 #6955 ITT Gremar Connector

d. Vacuum hose fittings:

Four lines terminated with MS 33515S6 end fitting

The Investigator should furnish the AIRO Facility Manager with desired pin and connector power and signal assignments. If any particular keyway orientations are desirable, such requirements should also be transmitted to the Facility Manager.

5.0 RACK-MOUNTED EQUIPMENT

5.1 NASA EQUIPMENT RACK

A standard double-bay equipment rack which attaches directly to the seat tracks is available for use by Investigators. It is

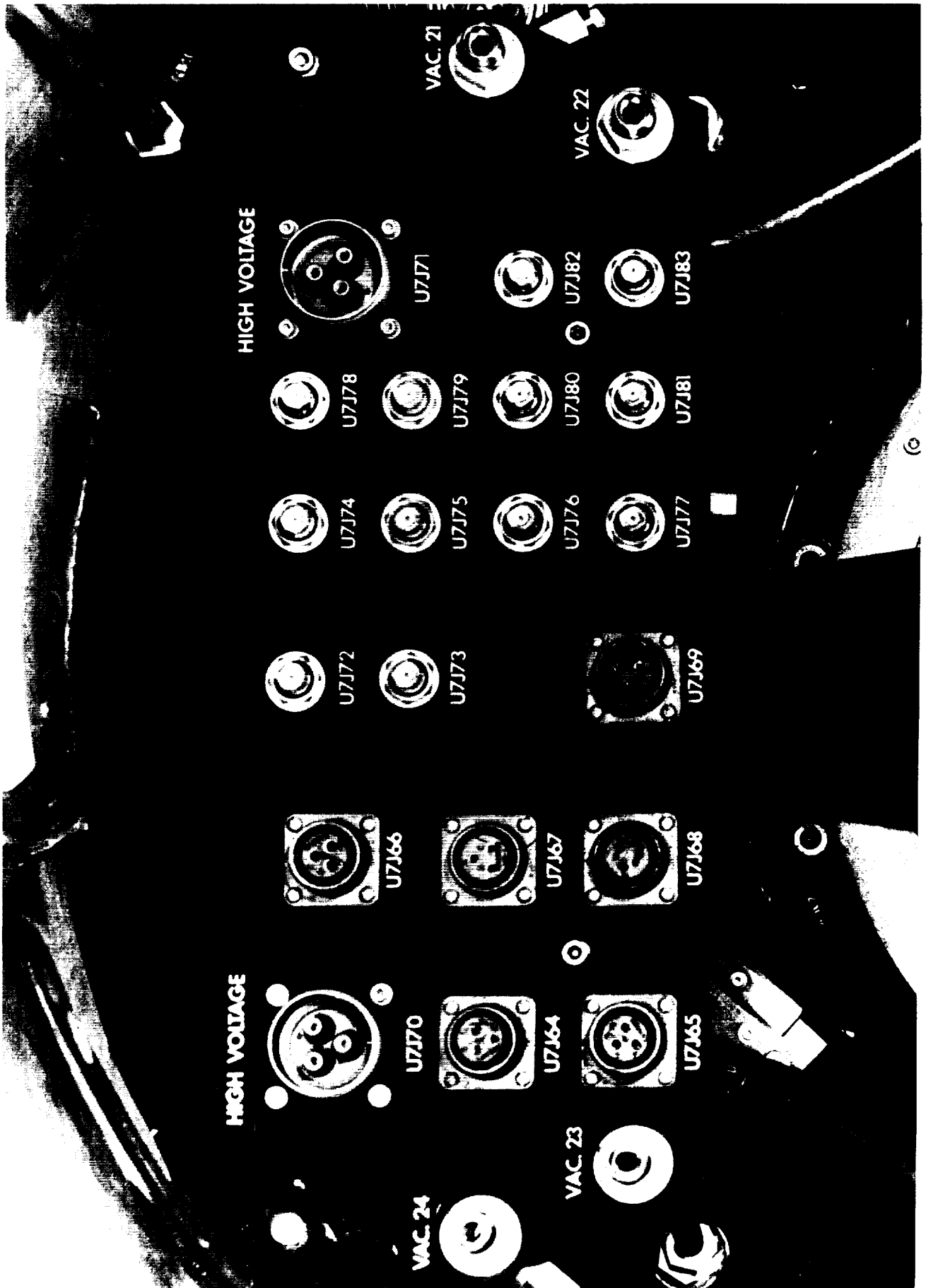


Figure II-13 Bent-Cassegrain Flange Section Connector Plate

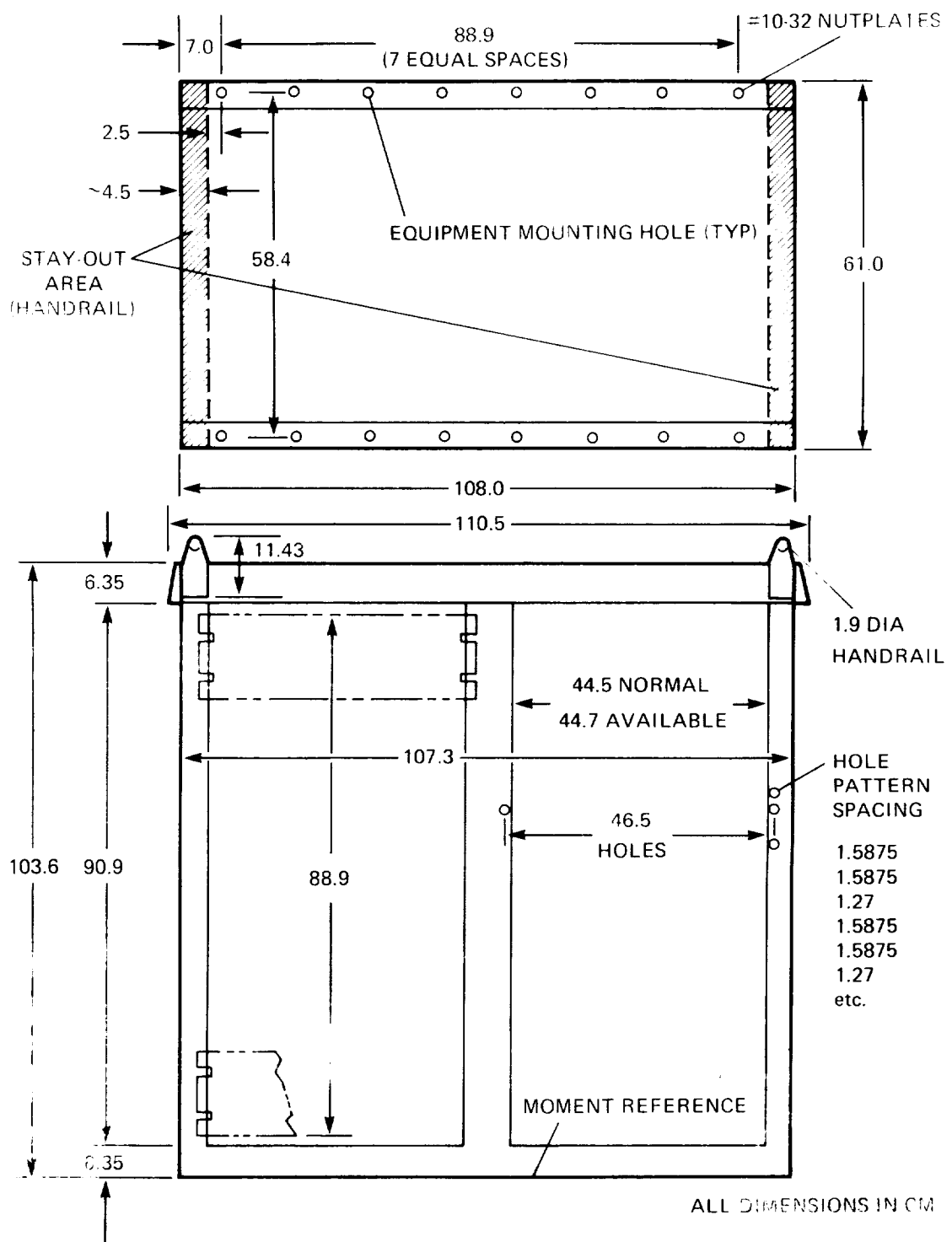


Figure II-14 Standard Double-Bay Rack Dimensions

MATING CONNECTOR DETAILS

U7P123
U7P124
U7P70
U7P77

Rowe Industries
No. 6RC1135
(Includes Clamp)

U7P165 = MS 3106A16 - 10S
U7P166 = MS 3106A16 - 10SW
U7P167 = MS 3106A16 - 10SX
U7P64 = MS 3106A16 - 10P
U7P65 = MS 3106E16 - 10PW
U7P66 = MS 3106E16 - 10PX

U7P168 = MS 3106A16S - 5S
U7P169 = MS 3106A16S - 5SW
U7P170 = MS 3106A16S - 5SX
U7P67 = MS 3106E16S - 5P
U7P68 = MS 3106E16S - 5PW
U7P69 = MS 3106E16S - 5PX

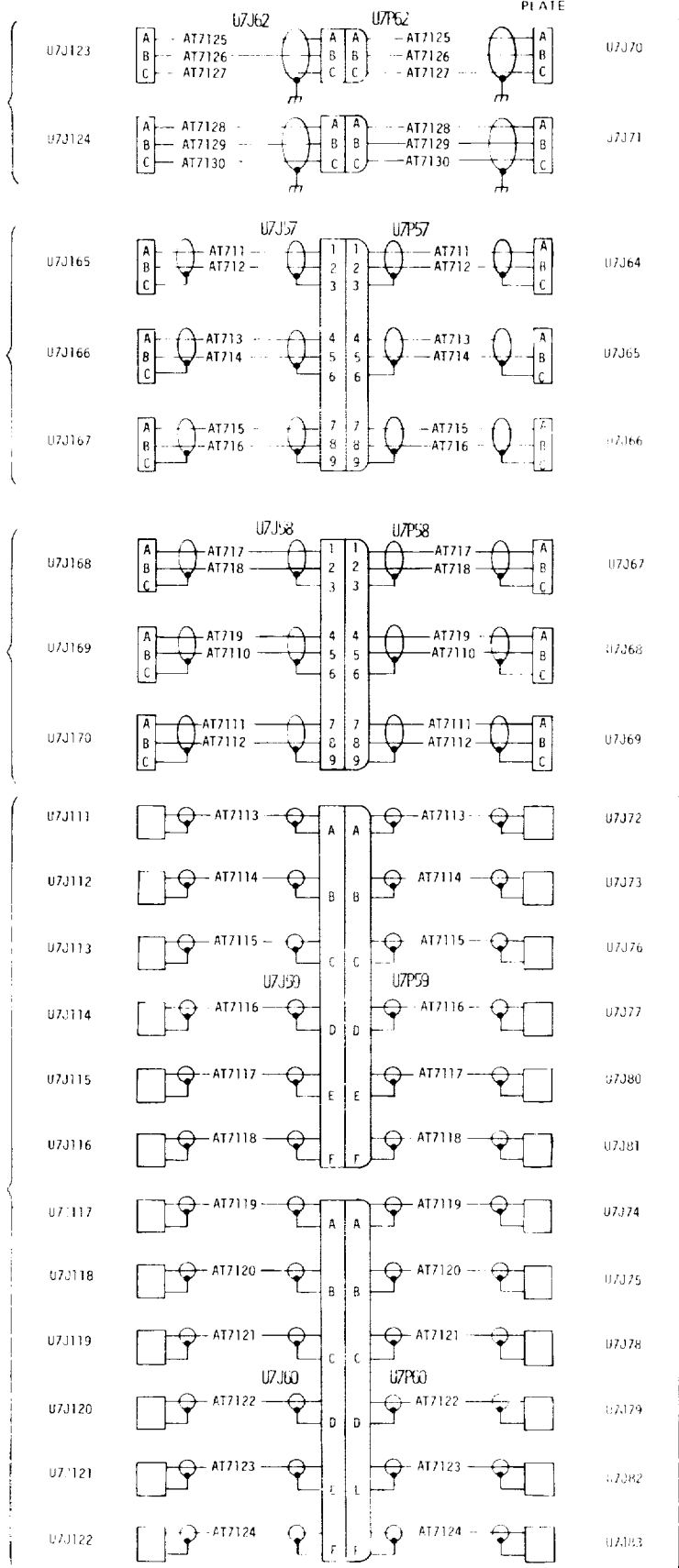
U7P11 U7P72
U7P12 U7P73
U7P13 U7P76
U7P14 U7P77
U7P15 U7P80
U7P16 U7P81
U7P17 U7P74
U7P18 U7P75
U7P19 U7P78
U7P20 U7P79
U7P21 U7P82
U7P22 U7P83

"BNC"
STYLE
CONNECTOR
PER
MIL HDBK 216

JUNCTION
BOX

INSIDE
FLANGE

FLANGE
SECTION
CONNECTOR
PLATE



1. High Voltage Lines.
2. 5 kv Maximum @ 15.24 km.

1. Power and Signal Lines.
2. #14, Twisted Pair, Shielded.
3. Type: MIL-W-16878, Type 2814/2, Voltage Rating: 400 V.

1. Power and Signal Lines.
2. #16, Twisted Pair, Shielded.
3. Type: MIL-W-16878, Type 2814/2, Voltage Rating: 400 V.

1. Coaxial, Signal Lines, Cable Type: RG-178 B/U, Z = 50 ohms.
2. Shield not tied to Aircraft ground. Method of grounding dependent upon application.

Figure II-15 Investigator's Junction Box/Connector Plate Interface

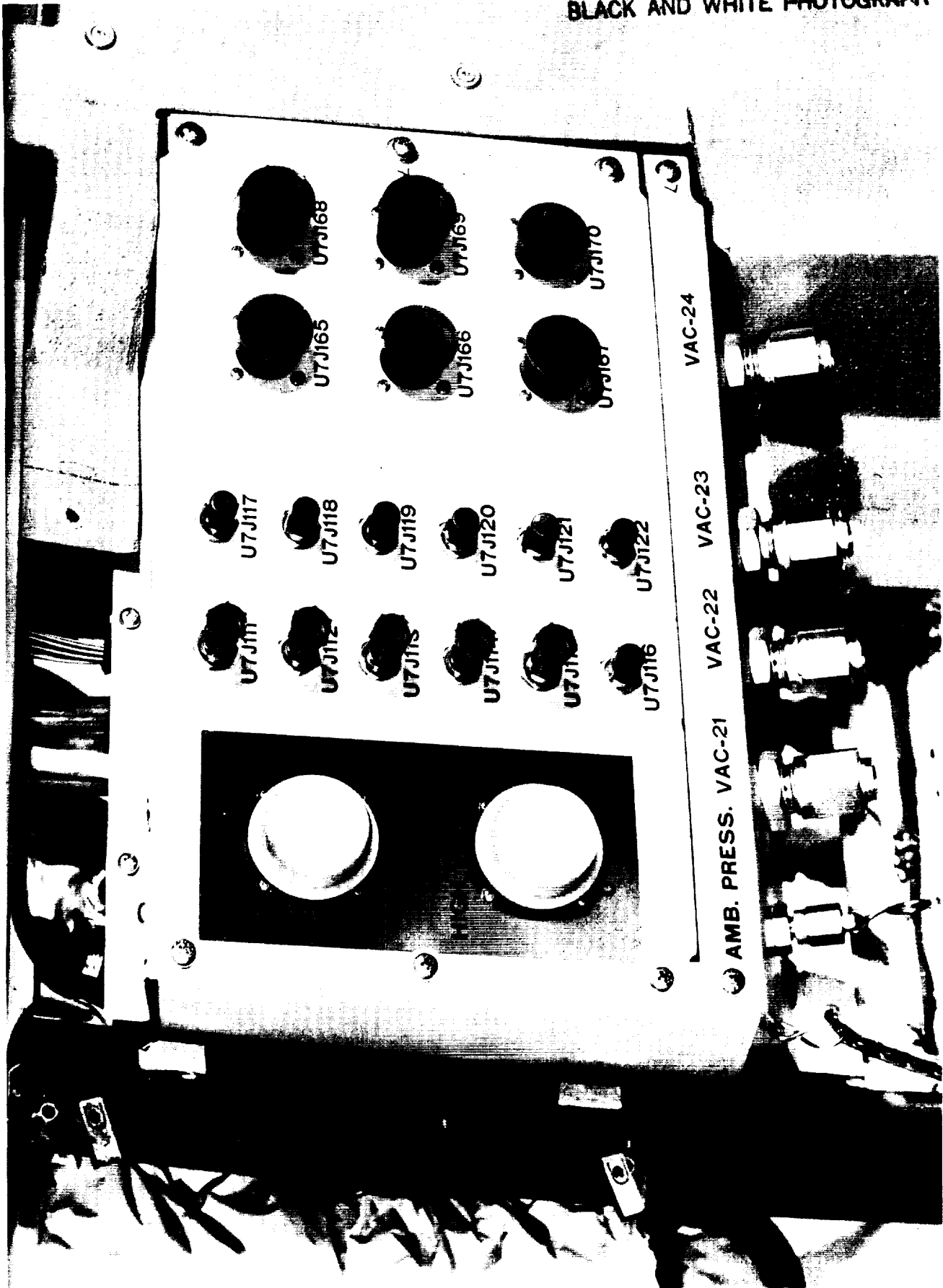


Figure II-16 Investigator's Junction Box

designed to accept standard 48.26 cm (19 inch) wide rack-mounted equipment. This rack must be used for mounting experimental equipment in lieu of laboratory-type electronic racks. Figure II-6 is a photograph of the rack and Figure II-14 gives pertinent dimensions. Equipment may be mounted facing fore or aft in either bay.

The AIRO Facility Manager has scale drawings of these racks which will be sent to Investigators on request. It is recommended that the Investigator make a preliminary scale layout of his equipment in the rack (taking into account the allowable loads and moments given in subsections II-2.2.1 through II-2.2.3) and prepare a list of sizes (panel height and depth of units) and weights. A rule-of-thumb in loading the racks is to place the heaviest items near the bottom when possible. The cognizant Ames engineer will check the loading and moments and will determine the internal support and bracing required to distribute the loads properly to the rack structure. A supply of specially-designed trays and straps is available for this purpose. When a rack is shipped to the Investigator for installing his equipment, a nominal supply of trays and straps (including NAS hardware, special tools, drawings and specifications) will be included.

5.2 CABLES, WIRE TYPES, AND SIZES

The cables interconnecting the cabin junction box (serving the rack-mounted equipment) and the Investigator's connector plate within the dome consist of the following:

- 3 - twisted pair, shielded #14 wires
- 3 - twisted pair, shielded #16 wires
- 2 - 3-wire high-voltage cables (5 kV Max @ 15 km)
- 12 - RG-178-U coaxial cables

Figure II-15 shows the cable configuration and gives the junction box and connector plate jacks and identification.

5.3 CONNECTOR TYPES, KEYING, AND PIN ASSIGNMENTS

The Investigator's junction box plate mounted on the left cabin wall (see Figure II-16) is for use in distributing control and signal lines to the instrument. The Investigator may require some or all of the following mating connectors. If difficulty is encountered in obtaining these connectors, contact the AIRO Facility Manager:

a. ITT Cannon-type circular connectors required:

U7P165	MS3106A16-10S (A95)
U7P166	MS3106A16-10SW (A95)
U7P167	MS3106A16-10SX (A95)
U7P168	MS3106A16S-5S (A95)
U7P169	MS3106A16S-5SW (A95)
U7P170	MS3106A16S-5SX (A95)

Cable clamp for the above is MS3057-8A

b. High voltage connectors to mate with Rowe cable assembly:

U7P123 #6RC1135 Rowe Industries - with cable clamp

U7P124 #6RC1135 Rowe Industries - with cable clamp

c. Coax connectors to mate with ITT Gremar bulkhead connectors:

U7P111 to U7P122 #6955 ITT Gremar connector

d. Vacuum hose fittings:

Four lines terminated with MS 33515-S10 end fitting

The Investigator should furnish the AIRO Facility Manager with desired pin and connector power and signal assignments. If specific keyway orientations are desirable, such requirements should also be transmitted to the Facility Manager.

6.0 OTHER INVESTIGATOR ON-BOARD EQUIPMENT

If the Investigator requires equipment not included in the instrument package or in the standard rack, he should communicate with the AIRO Facility Manager for specific instructions.

7.0 EQUIPMENT CERTIFICATION FOR SPECIAL EQUIPMENT

The design and construction of any special, or non-rack-mounted equipment may be discussed with Ames personnel at any time.

Investigators are required to submit detailed drawings of such equipment which show dimensions, materials, bolt types and patterns, and component weights. If possible, photographs of the equipment should also be furnished. Stress calculations must accompany the drawings. These calculations must include at least the following: load analysis of floor seat tracks, analysis of support and tie-down structure, and an analysis of restraining structure for components.

All of the above material should be submitted at least eight weeks prior to scheduled installation of the equipment aboard the aircraft. A longer required lead time may be specified by the Facility Manager in cases of complex installations. The material will be reviewed by Ames or by a contractor under Ames supervision, and changes will be requested as needed. Preliminary approval should be obtained from the AIRO Facility Manager prior to shipment of equipment.

Actual equipment construction, weight, center of mass, and resultant loading are verified at Ames before final approval for installation aboard the aircraft is given. Allow sufficient time for this verification when planning installation time.

7.1 AIRCRAFT FASTENERS AND WELDING

Aircraft structural fasteners (MS or NAS standards) *must* be used for all structural members. These fasteners must be secured by self-locking nuts, lockwashers, or safety wire. In addition to mandatory use for structural members, this type of hardware should also be used for other elements of the equipment whenever possible. Data sheets giving detailed nomenclature and engineering specifications for this hardware are available on request from the AIRO Facility Manager. In addition, standard hardware items required by the Investigator will be supplied by ARC on request.

Welding of structural members of experimental equipment is acceptable. However, it *must* be high-quality work performed by a welder currently certified to the MIL-T-5021C Specification.

7.2 HIGH VOLTAGES

Reduced pressure enhances the possibilities of corona discharge and of arcing between high-voltage components and ground. If a given voltage will arc over a gap of length X at sea level, then that same voltage will arc over a gap (of the same geometry) of length approximately $1.3 X$ at 2.4 km, approximately $2 X$ at 7.6 km and approximately $5 X$ at 14.5 km pressure altitude. These conditions should be taken into consideration in equipment design by increasing lead separations, potting high-voltage components in insulating material (if thermal effects are minimal), sealing in fluorine-inert chemical, and avoiding all sharp bends, extended wire ends, solder peaks, etc.

High-voltage portions of an electronics package should be clearly marked. Electrical and mechanical interlocks should be used where practical. Contacts, terminals, etc., having voltages above 50 V with respect to ground should have barriers or guards provided to prevent personnel from accidental contact.

8.0 CONSTRUCTION GUIDELINES

8.1 STRIPPING INSULATION

Attachment of wire to connectors, terminals, printed wiring boards, etc., requires the removal of insulation to expose the conductors. When performing the stripping operation, remove no more insulation than is necessary. Stripping may be accomplished in many ways; however, the following basic principles should be practiced: (1) Make sure all cutting tools used for stripping are sharp. (2) When using special wire-stripping tools, adjust the tool to avoid nicking, cutting, or otherwise damaging the strands. (3) Inspect each wire end and discard damaged wires before proceeding with soldering or crimping operations.

8.2 SOLDERING

One of the most common problems Investigators encounter is broken solder joints. Such failures frequently delay or abort flight programs. Recommended soldering practices are outlined in Section VII.

8.3 ELECTRICAL WIRING

When wire or cable bundles are used internally in a chassis, to connect different chassis together, or connect from chassis to connector mounting plates, etc., the following guidelines apply:

- a. It is often advantageous to have a number of wire groups individually tied within the wire bundle for ease of identity at a later date.
- b. To improve the appearance and to minimize the possibility of insulation abrasion, arrange wire groups and bundles so the wires lie parallel to each other.
- c. Bends in wire groups or bundles should not be less than ten times the outside diameter of the wire group or bundle. However, a bend three times the diameter is acceptable to facilitate connections to terminal strips, provided the wire group or bundle is supported at each end of the bend.
- d. Route and support wiring and conduits to prevent relative movement.

- e. Provide protection against chafing between wires or other objects.
- f. Provide extra protection where wires or cables may be subjected to rough handling.
- g. Soft insulation tubing (spaghetti) is not regarded as satisfactory mechanical protection against abrasion or considered a substitute for proper clamping or tying.
- h. Secure all wiring so it is electrically and mechanically sound and neat in appearance. Plastic cable ties are acceptable.
- i. Use clamps lined with nonmetallic material to support the cable bundle along the run. Tying may be used between clamps, but should not be considered as a substitute for adequate clamping.
- j. Adhesive tapes deteriorate with age and, therefore, are not acceptable as a clamping means.
- k. Cables should not be routed through the equipment mounting bases and should be supported in a manner that will not interfere with the operation of vibration isolators.

8.4 VIBRATION CONSIDERATIONS

To avoid failures caused by vibration, do not mount electronic parts weighing over 14 grams on printed wiring boards by leads alone. Provide additional mechanical support by use of clamps or brackets. Check assembled chassis for components that may be subject to vibration and provide additional restraining hardware (straps, brackets, etc.) where necessary.

8.5 FABRICATION CHECK

Make sure all fasteners are properly tightened. Remove any burrs or sharp corners that may cause injury to personnel. Remove any loose or spattered solder, metal chips, filings, or other foreign material which might affect equipment operation.

C-141 AIRBORNE INFRARED OBSERVATORY

INVESTIGATOR'S HANDBOOK

S E C T I O N I I I

TEST, INTEGRATION AND MISSION PREPARATION

1.0 INVESTIGATOR EQUIPMENT TEST

It is expected that the Investigator will have conducted sufficient inspections and tests to assure proper operation of his equipment under ambient conditions and whatever environmental conditions are available to him, prior to his arrival at NASA/ARC. However, it may be to the Investigator's advantage to perform additional tests on his equipment before attempting operation on the simulator or integration with the aircraft. For example, any evidence of shipping damage would be a good reason to repeat equipment tests. Also, in the event the Investigator has not previously had an opportunity to check his equipment at the environments to be encountered, tests of sensitive components are recommended. The following paragraphs indicate available facilities.

1.1 STATIC TESTING

Static tests are those used to verify the integrity of end-to-end signal paths, and to insure that input stimuli result in the proper responses. They may be conducted by the Investigator at his home facility, or may be accomplished, or repeated, at Ames in various available facilities including the AIRO Simulator and the R&QA Environmental Laboratory.

1.2 ENVIRONMENTAL TESTING

An environmental test laboratory is currently maintained, operated, and available for testing parts, components, subassemblies, and completed systems in the environments of temperature, altitude, humidity, vibration, acceleration, shock, acoustics, noise, and thermal vacuum, and to conduct measurements of weight, center of gravity, and dynamic balancing. This facility is available for use by the Investigator. Arrangements may be made through the C-141 AIRO Facility Manager.

1.3 SUPPORT TEST EQUIPMENT

General-purpose test equipment and other instrumentation required during the assembly, integration and test sequence can be arranged for and provided through the Facility Manager. The NASA/ARC Reliability and Quality Assurance Office has an Instrument Control System available, which allows general-purpose equipment to be obtained on loan for a short-term basis during system integration and testing. Equipment available within the Airborne Science Office, including characteristics of each instrument, is listed in Section VII, Reference E.

1.4 CLEAN ROOM

Clean rooms are maintained by R&QA and are available for Investigator use to process or assemble contamination-sensitive articles, or to examine articles or materials for viable or non-viable particles. The three primary classes of clean rooms available are, Class 100, Class 10,000 and Class 100,000.

2.0 SYSTEM INTEGRATION AND TESTING AT NASA/ARC (AMES SIMULATOR)

2.1 GENERAL CONSIDERATIONS

Most instrumentation for modern infrared astronomy is already designed to function properly on a mountaintop in an open telescope dome at wintertime temperatures down to -30°C and often in close proximity to the RFI environment of one or more television transmitters running at full legal power. However, additional environments of high-G force loading, vibration, and acoustical noise will be encountered in the C-141 AIRO and their effects on design must be carefully evaluated by the Investigator.

Investigator equipment integration and test activities will be a cooperative effort between NASA/Ames and the Investigator to assure that detector apparatus will function properly aboard a jet aircraft operating at high altitude.

The integration activities assure that the Investigator's hardware and ancillary equipment are assembled and tested in a workmanlike manner, that designed-in reliability and quality integrity are maintained, and that mechanical and electrical interface problems are promptly recognized and resolved consistent with established schedule and economic restraints. Initial integration using the Ames Simulator is recommended in order to minimize the time required for installation in the aircraft. Particular attention will be given to life-support aspects such as the integrity of seals, windows, etc., which could depressurize the aircraft in the event of failure.

2.2 MECHANICAL CONFORMANCE CHECK

As early as practical during Investigator equipment integration, a mechanical conformance check will be performed to determine that the design constraints listed in Section II-2.0 have been met. This check will include the following:

- Weight
- Center of gravity
- Dimensional compliance

Equipment rack center of gravity and tip-over moment
Cabling; parts, materials and schematic compliance inspection

2.3 VIBRATION AND SHOCK

If there is any doubt concerning the ability of the system to operate under the expected vibration and shock environments, arrangements should be made with ASO to run special system environmental checks in the R&QA Environmental Lab prior to integration.

2.4 ELECTRICAL POWER CONSUMPTION CHECK

The electrical power consumption will be checked and recorded with the system in operation.

2.5 AMBIENT, STATIC PERFORMANCE CHECK

The Investigator will normally complete a static performance check at ambient conditions to verify that all cabling is correct and the system operating properly before simulating aircraft temperature and pressure environments.

2.6 OPERATING ALTITUDE AND TEMPERATURE

A final check of the Investigator's equipment operating at normal aircraft environments of temperature and altitude will complete the initial integration tests.

3.0 INTEGRATION AND CHECKOUT AS PART OF THE AIRO

The purpose of integration and checkout aboard the aircraft is to demonstrate that the Investigator's equipment is compatible with existing systems, and that the total integrated system is ready for an operational mission. It is at this time that the Investigator Team should be prepared to function on an around-the-clock basis. Normally it is expected that integration and checkout will be complete and the first flight scheduled within 24 to 36 hours from initial entry on the aircraft. Integrations taking longer than 48 hours can result in an aborted mission, the instrumentation removed back to the simulator, and the aircraft made available to the next Investigator on the scheduled observing sequence. This policy is made necessary by the great competition for observing time on the C-141 AIRO and the fact that the C-141 AIRO complex is only providing a return to the scientific community during those hours when it is on station with functioning apparatus at the telescope focus.

3.1 INSTRUMENT PACKAGE INSTALLATION

3.1.1 Direct-Cassegrain Installation

The instrument package is bolted to the telescope with 3/8" - 16 bolts furnished by ARC (see Figures II-9 and II-10). Cables from the instrument package are then fed through the air bearing aperture and the open port of the window wheel to the Investigator's interface connector mounting plate (see Figure II-2 and II-11). Cable tie points will vary, depending on configuration of the Investigator's cables, but must be sufficient to prevent damage. If required, the dome will then be mounted and the telescope balanced by ARC personnel.

3.1.2 Bent-Cassegrain Installation

If requested by the Investigator, ARC will furnish a special mounting plate for mounting of the instrument package. These special mounting plates can be designed to provide the necessary pressure seals so that open-port viewing may be accomplished without use of the pressure dome. Other mounting plates may be designed for instrument installation on tabs at levels 1, 2 or 3 as required by the instrument optical system. However, if open-port viewing is desired, the pressure dome will have to be used in order to affect a pressure seal. The mounting plate/instrument assembly is then mounted to the flange section at the appropriate level with hardware furnished by ARC (see Figures II-4 and II-5) and cable connections are made to the instrument flange connector plate (see Figures II-11 and II-12). After all mounting hardware is attached, cables properly routed and secured, and the pressure dome or plate installed, the telescope is then balanced.

3.2 EQUIPMENT RACK INSTALLATION

The Investigator's equipment rack(s) will be loaded aboard the aircraft, installed and attached directly to the seat tracks by trained NASA personnel. Questions regarding the rack installation may be directed to the AIRO Facility Manager.

3.3 CABLE INSTALLATION AND CHECKOUT

Wiring and cables should be inspected for routing and support to:

- a. Prevent chafing and abrasion
- b. Prevent mechanical strain that would tend to break conductors or connectors

- c. Prevent excessive movement in areas of high vibration
- d. Provide adequate bend radius to prevent damage or excessive distortion of the wiring or cable
- e. Minimize electrical interference between wires, cables, and equipment
- f. Permit ease of maintenance, inspection and testing
- g. Permit ease of connection and disconnection

3.4 INSTALLATION INSPECTION

Installation and pre-flight inspection, at the operational or line level, consists of checking the Investigator's equipment (racks, instrumentation, experiment, cabling and wiring) for flight readiness. This is accomplished by performing visual examination and request of functional tests to discover defects and malfunctions which, if not corrected, could adversely affect safety or mission accomplishment.

In general, the ARC Aircraft Inspection Branch will conduct inspections, and make decisions relative to acceptable workmanship. They will monitor inspection records during systems integration progress, make suggestions pertaining to alterations, establish acceptable hardware standards, and inspect Investigator's equipment that has been installed aboard the AIRO. Corrective action will be requested on any major discrepancy that is discovered, and reinspection will be performed. The Reliability and Quality Assurance Office is available to provide technical support to the Investigator if such problems arise.

3.5 EMI/EMC TESTING

The purpose of EMI testing is to demonstrate that Investigator equipment and all related subsystems operate satisfactorily in the C-141 environment, and are compatible with the aircraft electrical and electronic equipment. The test will be a joint effort by NASA/Ames personnel and each Investigator.

3.5.1 General Test Requirements

The EMI Tests will be conducted aboard the aircraft and flight and Investigator crew positions will be occupied by personnel qualified to operate and monitor the equipment at the station. A test conductor will be appointed and any equipment malfunction or deviation from normal shall be reported to him.

3.5.2 Test Description

Those pieces of equipment which are highly susceptible to electromagnetic interference, yet passive in nature, should be placed in operation early in the test. All Investigator's equipment will be turned on in sequence, the sequence to be determined by analysis of their respective susceptibility and interference-generating characteristics. The equipment turn-on procedure will be accomplished with power supplied from the Ground Power Unit.

The aircraft engines will be started, ship's power switched to internal, and all aircraft openings secured, as for flight. Each piece of Investigator's equipment will then be sequentially turned on and operated while monitoring the effects of the operation on susceptible equipment in the aircraft-Investigator system complex.

3.6 PRE-FLIGHT TEST

It is recommended that the Investigator prepare a check list, including GO/NO GO criteria, for use during the pre-flight test. The test should be complete enough to satisfy the Investigator that his equipment and supporting equipment furnished by ARC are properly operating. The test shall be sufficiently documented to provide inputs to the Test and Integration Review and the Airworthiness and Safety Review.

4.0 TEST AND INTEGRATION REVIEW

Following integration and pre-flight testing, a formal review will be held to evaluate readiness for flight of all systems. Particular attention will be given to problems encountered which may require modifications to the original mission profile and affect flight plans. In addition, the records of any malfunctions of prime test equipment or the Investigator's equipment will be reviewed (ARC Form 158 provides a convenient means of recording such events as well as the actions taken to remedy the problem and prevent future occurrences).

The participants to the review will include the Investigator, Facility and Program Managers, the R&QA Representative, and other personnel as may be required to provide necessary inputs.

The review will include the following:

- a. Results of environmental tests
- b. Results of System Integration and testing with simulator
- c. Integration and checkout on the AIRO

- d. Nonconformances observed
- e. Corrective actions taken
- f. Action item assignments with schedule for completion

A Test and Integration Review report will be prepared by the Program Manager for Investigator concurrence. The report will include a summary of the discussions and a list of action item assignments, and will serve as an input to the Airworthiness and Safety Review. The System Integration and Test facilities at ARC will be available to the Investigator teams to aid in the solution of problems which arise during the Test and Integration Review.

5.0 AIRWORTHINESS AND SAFETY REVIEW

The Project Manager and Facilities Manager will review the Flight Plan and the Test and Integration Review report for any factors which may affect airworthiness and flight safety. Ames Management procedures require that the chairman of the Airworthiness and Flight Safety Review Board review all flight programs to determine whether a formal review by the Airworthiness and Flight Safety Review Board will be required. Formal review by the board is generally required whenever there is a configuration modification of the C-141 aircraft, whenever a previously approved flight envelope is exceeded, or whenever unusual operating procedures are required. In such instances the Investigator may be asked to assist Ames personnel in preparing for the review by the Airworthiness and Flight Safety Review Board.

6.0 FLIGHT PLAN DEVELOPMENT

The flight plan will be based on mission profiles previously coordinated with project personnel (Reference Section II-1.3). It will be an important input to the Test and Integration Review and the Airworthiness and Safety Review. The flight plan shall include, but is not limited to, the following:

- a. Statement of mission objective
- b. Minimum success criteria
- c. Detailed sequence of events during flight - including requirements for calibration checks, data runs, emergency procedures, etc.
- d. The plan shall be sufficiently detailed so supporting personnel will know exactly what will be required of them during flight.

7.0 PRE-FLIGHT BRIEFING

Pre-flight briefings are scheduled to assure that all flight personnel are familiar with the flight plan and thoroughly understand mission requirements. Attendance is mandatory. Operating procedures, emergency procedures, pertinent aircraft regulations, etc. will be discussed. Investigators are encouraged to raise questions concerning any aspect of the mission that they feel has not been adequately covered.

8.0 MANIFEST PREPARATION

Personnel and equipment will not be permitted aboard the aircraft unless listed on the manifest. The manifest will be prepared by NASA personnel, but input from the Investigator is required. It is the Investigator's responsibility to make certain that the Facility Manager is aware of all personnel of the Investigator's organization and of all equipment required to be aboard for each flight.

For foreign flights it is particularly important that the Investigator provide a detailed list, even including spare parts, to facilitate customs clearance.

9.0 INSURANCE

Commercially available accidental death and double indemnity for accidental-death riders to whole or term life insurance policies may not provide protection for NASA flights. At this time, non-civil service and contract personnel participating in flights of NASA aircraft are responsible for ascertaining the extent of their individual insurance coverage, and for arranging any additional coverage that may be required.

C-141 AIRBORNE INFRARED OBSERVATORY

INVESTIGATOR'S HANDBOOK

S E C T I O N I V

PROPOSAL PROCEDURES

1.0 GENERAL DESCRIPTION

NASA welcomes proposals from any domestic or foreign scientist who desires to use the Airborne Infrared Observatory for astronomical research, or who desires to develop an instrument necessary for a specific airborne research program.

1.1 PROPOSAL GUIDELINES AND CONSTRAINTS

Two types of proposals are suggested herein. Respondents may propose for one or both types. A separate proposal should be submitted for each scientific program.

1.1.1 Type 1: Research Requiring Development of New Instruments

Many research programs will require the development of new or unique instrument systems in order to fulfill scientific objectives. Proposals requesting NASA support for the development of these systems must be strongly justified by the scientific merit of the research for which the system is intended. NASA encourages groups with similar interests to collaborate since funds may be limited and duplication normally will not be possible. As instruments developed under NASA grants or contracts become operational, they will be assigned in most cases to the Airborne Infrared Observatory and subsequently be made available for use by other qualified observers.

1.1.2 Type 2: Research Using Existing or Planned Instrumentation

Proposals in this category should be for observational programs which can use the respondents' own existing equipment or instrumentation belonging to the Airborne Infrared Observatory.

1.2 PROPOSAL CONTENT

Proposals submitted in response to this announcement should contain the following material assembled in the order given:

1.2.1 Technical

- a. Cover Letter: Each proposal should be prefaced by a cover letter signed by an official of the Investigator's organization who is authorized to commit the organization to the proposal and its content.

- b. Title Page: The title page should contain the following:
 - (1) A short descriptive title for the proposed investigation
 - (2) Name of proposing organization(s)
 - (3) Names, full addresses, *telephone numbers*, and affiliations of all principal Investigators
 - (4) Date of submission
- c. Summary or abstract: The title page should be followed by a concise statement of what the proposed investigation is, how it will be performed, the anticipated results, *and a table listing specific characteristics of the instrument (wavelength range, resolution, filter pass band, detector, etc.)*.
- d. Background and justification: A description of the research work that motivates the proposal and a statement demonstrating the need for the proposed investigation. This section should specifically describe how the Investigator expects the C-141 AIRO to help in solving experimental problems in his field of interest.
- e. Objectives and major requirements: A brief statement of what the proposed experiment is designed to accomplish and what technical requirements must be met to insure success of the experiment.
- f. Approach:
 - (1) Concept of the investigation
 - (2) Method and procedures for conducting the experiment
 - (3) Performance criteria for success of the experiment
 - (4) Supporting studies involved in the investigation
 - (5) Plans for post-flight evaluation of experimental data
- g. Ground support and logistical requirements
- h. Expected results: A general indication of the results expected from the investigation if successful, and their implications for the Investigator's field of study.

1.2.2 Management

- a. Work Plan
 - (1) Program management plan, giving the names of the persons responsible for carrying it out
 - (2) Names, addresses, and experience and education resumes of the program's key scientific and management personnel

- (3) Performance schedule, indicating manpower requirements and lengths of time needed to complete specific phases of the proposed work
- b. Cost Plan (United States Proposals Only). If NASA funding support is required, a cost plan containing the following must be submitted:
 - (1) Cost estimates for direct labor, including individual manhours and rates for the personnel involved
 - (2) Estimated costs for materials
 - (3) Travel costs
 - (4) Overhead and general and administrative costs, with descriptions of the method of their calculation and the method for applying them to labor and other costs
 - (5) Other costs (to be explained)
 - (6) A quarterly spending curve keyed to the work schedule
 - (7) Total cost

1.3 ADDITIONAL PROPOSAL INFORMATION

NASA Handbook, NHB 8030.1A, *Opportunities for Participation in Space Flight Investigations*, dated April 1967, contains further general information on preparation of proposals for space experiments. This handbook is available from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22151 (No. 75724).

1.4 PROPOSAL ROUTING

Copies of each proposal should be submitted as follows:

- a. Proposals from all United States sources other than NASA:
The official proposal and one copy to:

Office of University Affairs
Code PY
National Aeronautics and Space Administration
Washington, D. C. 20546
- b. Proposals from foreign sources: Proposals for participation by individuals from outside the United States should be sent first to the official national agency of their country responsible for space and/or scientific activities. After review, that agency should forward endorsed proposals to the NASA Office of International Affairs (Code I), Washington, D. C. 20546, after which they will go through the same evaluation and selection procedure as United States originated proposals.

Proposals should be submitted in English. Should a proposal be selected, NASA will arrange with the sponsoring national agency for the proposed participation on a cooperative (no exchange of funds) basis, in which NASA and the foreign sponsoring agency will each bear the cost of discharging their respective responsibilities. Informal copies of the proposal may be sent directly to NASA.

c. Proposals from *all* sources: Ten copies to:

Mr. Robert M. Cameron
Airborne Science Office (M. S. 211-12)
Ames Research Center
Moffett Field, California 94035

Telephone: (415) 965-5338

and three copies to:

Mr. Michael E. McDonald
Code SG
National Aeronautics and Space Administration
Washington, D. C. 20546

Telephone: (202) 755-3616

1.5 PROPOSAL ACCEPTANCE

NASA acceptance of any proposal involving use of the C-141 AIRO requires adherence to the guidelines and constraints presented in this Investigator's Handbook.

C-141 AIRBORNE INFRARED OBSERVATORY

INVESTIGATOR'S HANDBOOK

S E C T I O N V

TRANSPORTATION, HANDLING & STORAGE

1.0 PREPARATION FOR TRANSPORTATION

Upon completion of the final tests at the Investigator's location it is recommended that each component be carefully identified as it is removed from the setup. Cables should be tagged to indicate to which connectors they mate. Frequently a series of photographs of the setup will be of help when retesting or installing the equipment at ARC. Sufficient drawings, sketches, and other documentation should be included. Those items which are fragile or subject to misalignment, etc., should be packaged with adequate cushioning in sturdy containers.

Care must be exercised in consolidating individual packages into a common shipping container. The packages must be adequately blocked to prevent damage to each other. Weight should be distributed as evenly as possible. Shipping containers should be marked with appropriate instructions such as Fragile, Handle with Care, This Side Up, etc.

1.1 TRANSPORTATION

The preferred method of transportation for critical components such as sensors is to hand carry them. Unfortunately, airline restrictions usually prevent all but small packages from being handled in this manner. Rules vary depending on the airline and the type of aircraft so the Investigator is urged to secure written confirmation of permission from appropriate airline officials to hand carry components if the package size is larger than can be placed under an aircraft seat. Air shipment is normally recommended for articles which cannot be hand carried.

In some cases the Investigator may wish to ship large items via truck. Many large transportation companies have vans especially equipped to handle electronic equipment and these are recommended.

Material shipped to ARC should be addressed as follows:

C-141 Airborne Infrared Observatory
National Aeronautics & Space Administration
Ames Research Center, M. S. 248-1
Moffett Field, California 94035

1.2 HANDLING

Following arrival of equipment at ARC, adequate handling equipment is available to prevent damage during intra-center transportation.

The Investigator should advise the C-141 AIRO Facility Manager of any unusual handling requirements. The Investigator is urged to supervise all movement of his equipment. In the event Investigator equipment arrives ahead of Investigator Team personnel, it will be placed in storage in an area adjacent to the C-141 AIRO maintenance facility. If items are critical in nature or are sensitive to normal ambient environments, they should be identified as such so that controlled bonded storage can be arranged.

1.3 STORAGE

Those items which will not be required for testing or installation during periods greater than 48 hours should be sent to the bonded storage facility. The facility will be accessible 24 hours a day, but prearrangement of off-duty hour transactions is requested whenever possible. The Investigator will indicate specific personnel authorized to remove his items from stores. Special arrangements can be made to store those items requiring unusual environmental conditions.

C-141 AIRBORNE INFRARED OBSERVATORY

INVESTIGATOR'S HANDBOOK

S E C T I O N V I

AIRO INFORMATION BULLETINS

AIRBORNE INFRARED OBSERVATORY
INFORMATION BULLETINS

From time to time the NASA/Ames Airborne Science Office will issue Information Bulletins which serve to provide concerned persons and organizations with information relative to new developments, changed proposal procedures, schedule changes, and other pertinent C-141 AIRO data. This section of the Investigator's Handbook provides a convenient place to file these Bulletins as they are issued.

C-141 AIRBORNE INFRARED OBSERVATORY

INVESTIGATOR'S HANDBOOK

S E C T I O N V I I

REFERENCE DATA

REFERENCE DATA

The material contained in this section has been inserted to provide to the Investigator a readily-available source of useful data. It is planned that material of interest will be added to the handbook from time to time. Investigators are encouraged to recommend data which would be of use to them for inclusion herein. Suggestions may be made to the C-141 Project Manager or Facility Manager at any time.

SECTION VII

REFERENCE A

C-141 AIRO PROJECT ORGANIZATION AND MANAGEMENT

The director of the Physics and Astronomy Programs, OSS, is responsible for overall direction and evaluation of the AIRO Project, as delegated by the Associate Administrator of the Office of Space Sciences. The Ames Research Center is responsible to the Physics and Astronomy Programs Office for the execution of the project as described herein.

The management, operation, and future development of the AIRO are under the cognizance of the Airborne Science Office (ASO). The Project Manager is Mr. Robert Cameron, Airborne Astronomy Missions Manager and a member of the C-141 IR Telescope Project Team. Mr. Cameron reports directly to the Chief of the Airborne Science Office and to the Program Office at NASA Headquarters. The functional organization of the AIRO Project is shown in Figure VII-A-1.

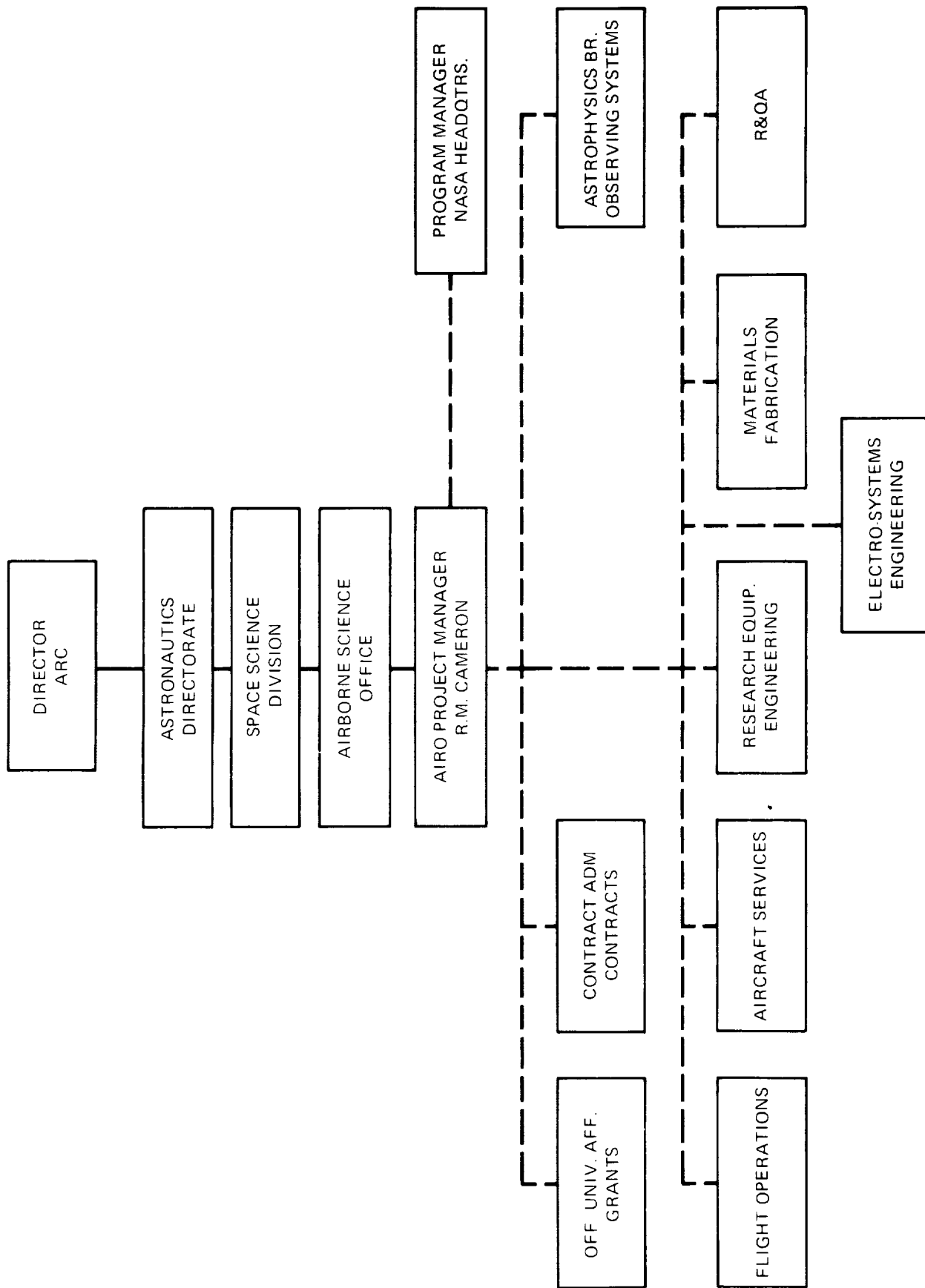


Figure VII-A-1 C-141 AIRO Project Functional Organization

SECTION VII

REFERENCE B

VARIATIONS OF THE TROPOPAUSE

AS A

FUNCTION OF SEASONAL VARIATIONS AND GEOGRAPHIC LOCATION

The far-infrared transmission of the upper atmosphere is a complex function of wavelength. However, the principal absorber is water vapor, and its effect can be very significantly reduced (although not completely eliminated) by operating the aircraft at altitudes well into the stratosphere, perhaps a kilometer above the measured break or discontinuity in the temperature lapse rate. This region at the knee in the atmospheric temperature-vs-altitude curve is known as the tropopause, the practical boundary between the troposphere and the stratosphere. A wet-air layer of ill-defined thickness is often found at the tropopause. This phenomenon is occasionally demonstrated visually by a thin cirrus cloud layer, although this layer is often so thin that it is invisible from the ground. It is possible that by ascending above the tropopause, an observer can reduce the total precipitable water vapor along the high-altitude ray path from greater than 50 microns to less than 5 microns, and in some long-wavelength spectral region, this can mean the difference between success or failure of an observation.

The distribution and seasonal variance of water vapor at altitudes above 10 km is not well understood. Systematic H₂O monitoring from the C-141 AIRO will serve three purposes:

1. The water vapor overburden data will provide real-time assistance to flight track planning for best infrared astronomical conditions.
2. The total mission H₂O record will be of value to the Investigator during post-flight analysis of the received IR flux.
3. A long range collection of previously unavailable high-altitude water vapor data will become available to research meteorologists and to the scientific community.

Figure VII-B-1 illustrates the tendency of the high tropical tropopause to follow the sun, making seasonal excursions into the middle latitudes of both hemispheres.

EXAMPLE 1 - San Francisco to Washington, D. C. in July would never go above 40° and would likely be under the tropopause. To overcome this, the flight path might run along just south of the Canadian Border from Seattle to Northern Maine, terminating perhaps at Loring AFB.

EXAMPLE 2 - Perth to Sidney would be quite feasible in July, but in January it would seem advisable to fly farther south (perhaps working out of Christ Church, New Zealand).

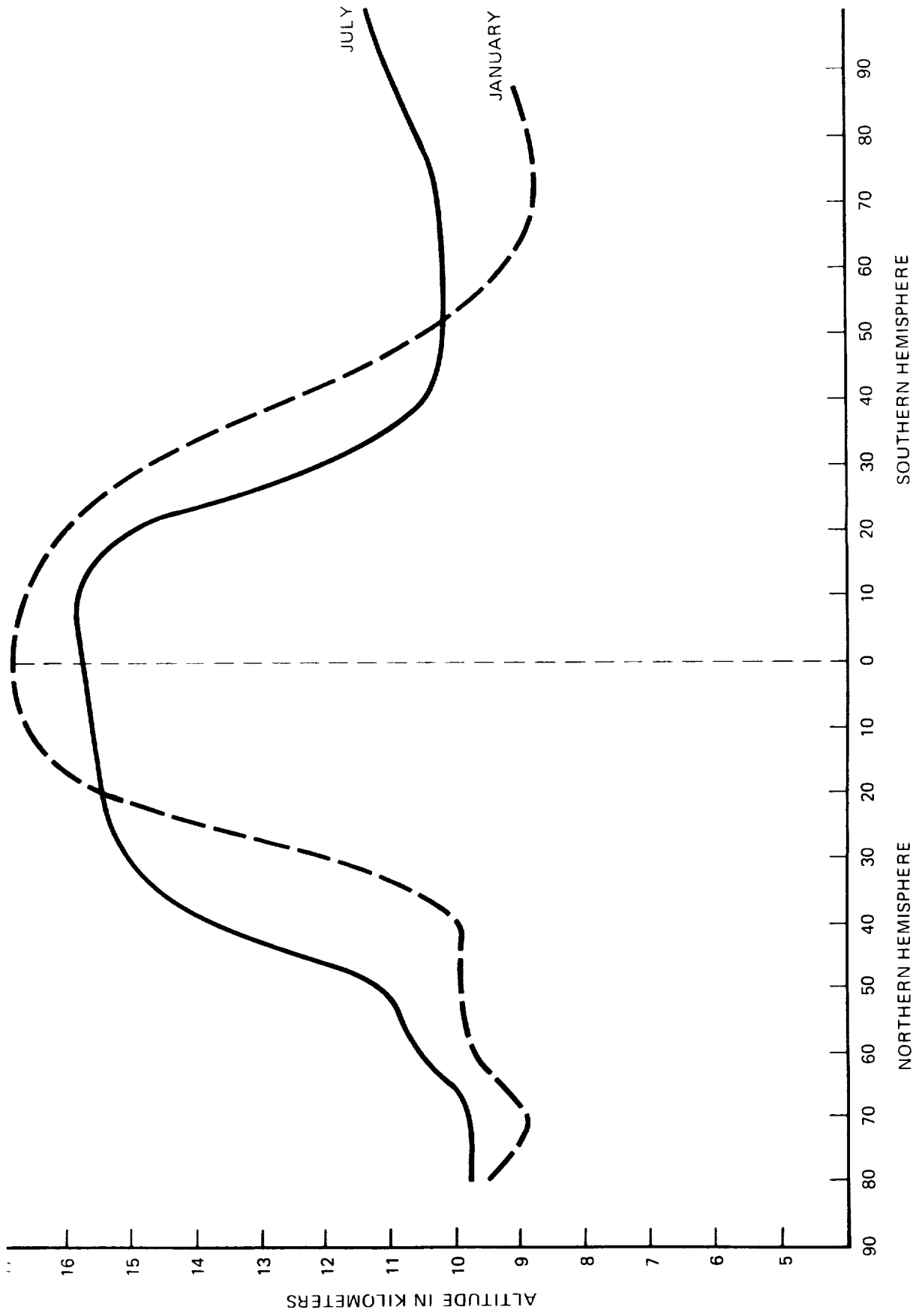


Figure VII-B-1 Semiannual Mean Tropopause Cross Section Pole-to-Pole

SECTION VII

REFERENCE C

LOADING CONSIDERATIONS FOR THE NASA/AMES DOUBLE-BAY EQUIPMENT RACK FOR THE C-141

1.0 GENERAL

Two effects must be considered in planning to load electronic equipment into the NASA rack. First, the overall effect of the rack load on the aircraft floor and attachment points requires a reasonable distribution of the load over the floor area and a low center of gravity (see Figure VII-C-1); second, the local effect of mounting equipment of various weights in the rack will determine the internal rack detailed strap configuration required to handle aircraft deceleration loading on the rack structure (see Table VII-C-1).

The rack is designed to accommodate standard 48.26 cm (19 inch) rack panels with electronic packages attached. The C-141 AIRO Facility Manager should be contacted for help with any unusual problems encountered in mounting equipment in the rack or if any components are not compatible with this configuration.

2.0 FLOOR AREA DISTRIBUTION

The total equipment load allowable on the standard two-bay NASA rack is 272 kg. This should be distributed fairly evenly among the four rack sections (front and back faces of each of the two bays - see Figure VII-C-2). This would be approximately 68 kg per section. However, this distribution can vary provided that the requirements of Figure VII-C-1 are met (136 kg per Face Pair - front of the two bays or back of the two bays and 136 kg per bay - front and back of one bay).

2.1 OVERTURNING MOMENT

Normally, when loading the rack, the heavy items should be located near the bottom to keep the total torque or overturning moment as low as possible. The maximum sum of the rack torque moments produced by the equipment and its placement as given in Figure VII-C-1 is 138 kg-m (see Figure VII-C-3).

3.0 PANEL LOADING

NASA and the FAA require safety factors in panel loading to handle 4.5 g vertical landing and 9.0 g forward deceleration. Table VII-C-1 presents data for use directly by designers and/or Investigators to determine what attachment parts are required to mount each component in the rack. The values given in Table VII-C-1 take into account the g-loads.

In addition to the weight distributions horizontally, as shown in Figure VII-C-2, and the torque moments of Figure VII-C-3, safety considerations require that there be no alignment of heavy panels fore and aft in any given bay (a typical correct mounting configuration is shown in Figure VII-C-4).

H Standard Panel Height (cm)	M _B (1) (4) (kg-m)	W _F (2) (kgs) Mounted Forward Side of Rack					W _A (2) (kgs) Mounted Aft Side of Rack				
		No Tray	Tray Only	Tray Plus Straps			No Tray	Tray Only	Tray Plus Straps		
				2	4	6			2	4	
8.89	1.30	10.5	16.0	21.4	26.9		15.9	20.7	25.5	30.4	
13.34	1.73	11.8	20.4	29.1	37.7	46.3	23.6	28.5	33.3	38.1	
17.78	2.59	15.9	24.5	33.2	41.8	50.4	31.8	36.6	41.4	46.3	
22.23	3.46	19.5	28.1	36.8	45.4	54.0	39.5	44.4	49.2	54.0	
26.67	4.32	23.6	32.2	40.9	49.5	58.1	47.7	52.5	57.4	62.2	
31.12	5.18	27.7	36.3	45.0	53.6	62.2	55.5	60.3	65.1	69.9	
35.56	6.06	31.8	40.4	49.1	57.7	66.3	63.6	68.5	73.3	78.1	
		These values assume no equipment mounted directly in line on Aft side.					These values assume no equipment mounted directly in line on Forward side.				

NOTES:

1. The allowable moment (M_B) at point "B" includes a 4.5g down factor.
2. The allowable load or weight (W_F or W_A) at the C.G. includes a 9g fwd. factor.
3. W = actual load or weight of equipment.
4. When the weight (W) requires the use of a tray the moment (M_B) can be disregarded.
5. The actual moment at point "B" is $M_B = WL$.
6. Compute Margin of Safety (M.S.) as follows:

$$M.S. = \left(\frac{\text{Rack Loading Allowable from Table}}{\text{Actual Moment, Load or Weight}} \right) - 1 \geq \text{ZERO}$$
7. Two straps (one on each side of component) increases the allowable loads (W_F by 8.64 kg or W_A by 4.8 kg)
8. For ease of handling, a tray is recommended when the item to be mounted is 22.7 kg or more.

See FIGURE VII-C-3 for additional details

TABLE VII-C-1
ALLOWABLE RACK LOADING

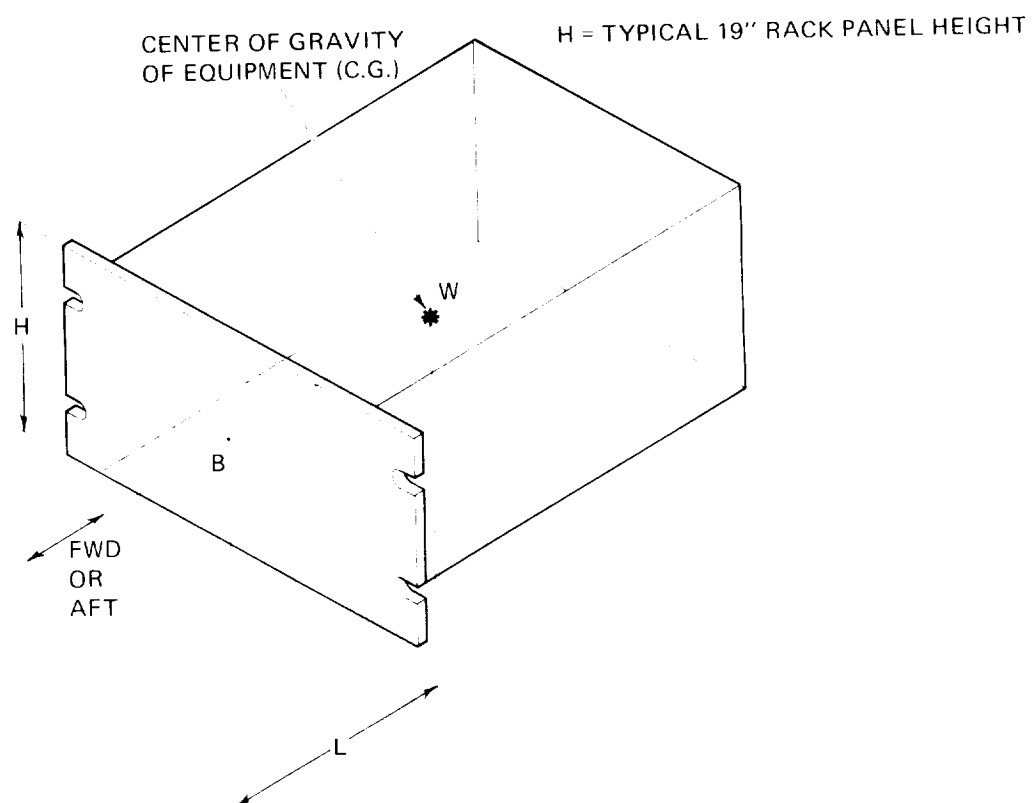


Figure VII-C-1 Rack-Mounted Equipment Center of Gravity

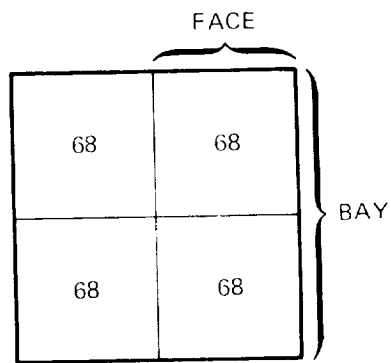


Figure VII-C-2 Plan View of Rack

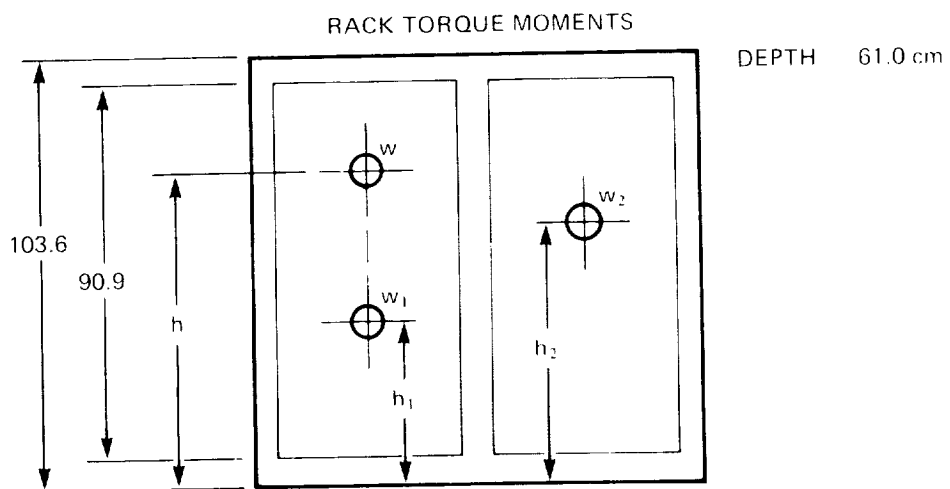


Figure VII-C-3 Rack Torque Moments

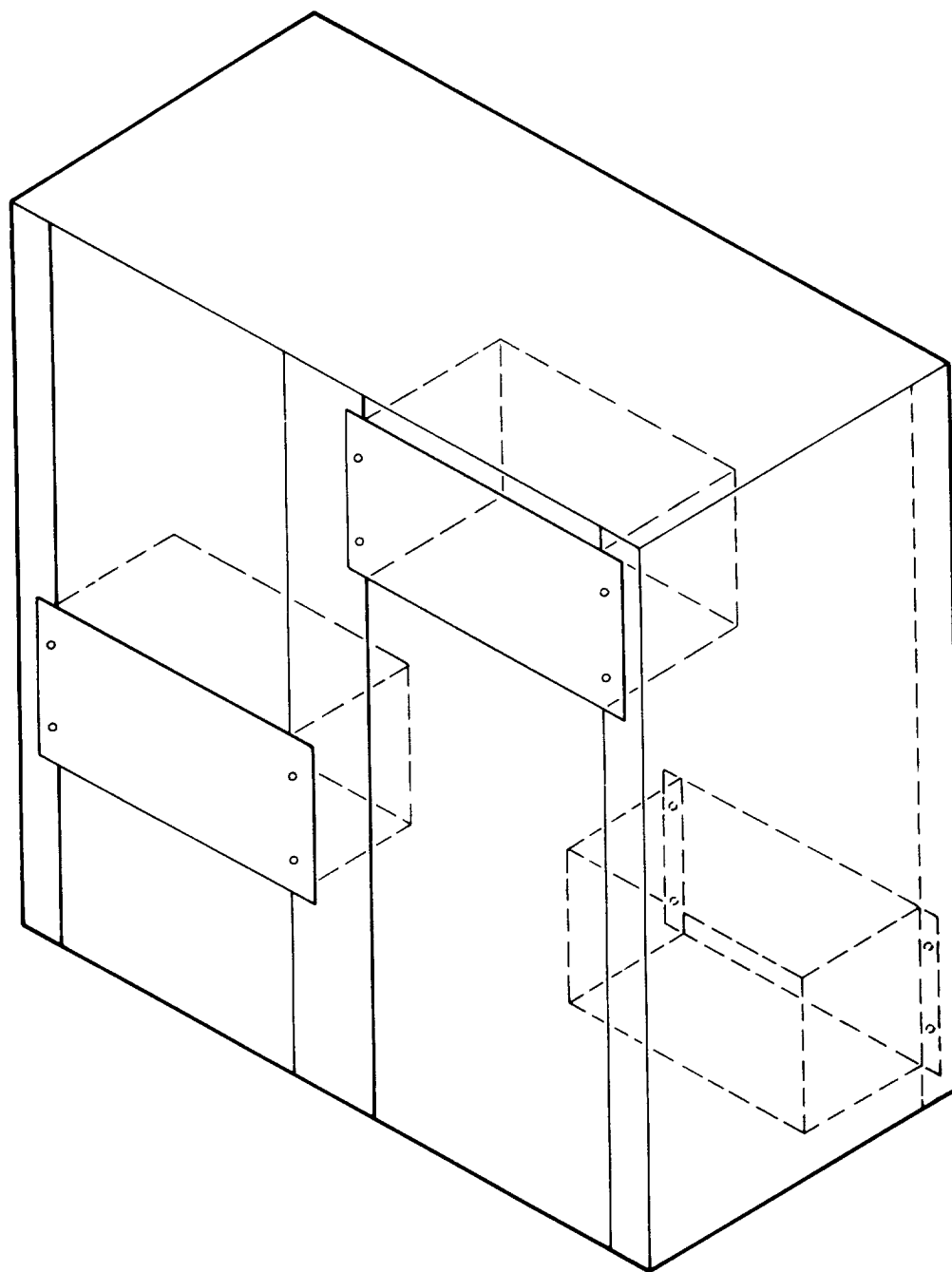


Figure VII-C-4 Typical Locations of Heavy Chassis Fore and Aft

SECTION VII

REFERENCE D

RECOMMENDED SOLDERING PRACTICES

Soldering Iron

Before starting the soldering operation, make sure that the iron tip is clean, smooth and well-tinned. When resistance soldering equipment is to be used, make sure that probes are clean.

Securing the Joint

Whenever possible make sure that the joint is mechanically secure before soldering. When this is not possible, as with MS connector contacts, make sure that the joint is held rigid during the cooling period.

Application of Heat and Solder

Apply flux-core solder at the exact point between the metal and the soldering iron and hold the iron directly against the assembly. Melt the solder on the joint, not on the iron. Place the soldering iron firmly against the junction; if heavy "rocking" pressure is necessary, either the iron does not have sufficient heat capacity for the job, or it has not been properly prepared, or both.

Heat Application Time

Do not apply heat to the work any longer than the time necessary to melt the solder on all parts of the joint. Use heat-sinks to protect delicate components such as transistors, diodes, etc.

Amount of Solder

Do not use any more solder than necessary. Do not pile up solder around the joint; this is wasteful and results in joints difficult to inspect. Care should be exercised with silver-coated wire to prevent wicking during solder application.

Soldering Iron Holder

When the soldering iron is not in actual use during operations, keep it in a holder. This will protect the operator against burns, and the iron against damage.

Protection Against Overheating

Do not allow the iron to overheat. Disconnect the iron when it is not in use between operations, or use a heat-dissipating stand which will keep the iron at a constant temperature.

Cooling the Solder Joint

When the solder joint has been made, hold the work firmly in place until the joint has set. Disturbing the finished work will result in a joint mechanically weak, and with high electrical resistance. Allow solder joints to cool naturally. Do not use liquids or air blasts.

Cleaning

If the correct amount of solder is used and procedure instructions followed carefully, there should be little or no excess flux remaining on the finished joint. If cleaning is necessary, remove excessive flux by brushing the joint with a stiff brush dipped in methyl alcohol sparingly, and avoid contact between alcohol and wire insulation. For cleaning printed-circuit connections, use a cotton swab-stick for small areas, and a lint-free clean cloth for large areas and board edges.

Acceptable Solder Joint

A good soldered joint will have a bright silvery appearance, with smooth fillets and feathered, not sharp, edges. The entire joint will be covered with a smooth, even coat of solder, and the contour of the joint will be visible.

Unacceptable Solder Joint

Any of the following indicate a poor solder joint, and are cause for rejection:

- a. Dull gray; chalky or granular appearance, evidence of a cold joint.
- b. Hair cracks, or irregular surface, evidence of a disturbed joint.
- c. Grayish, wrinkled appearance, evidence of excessive heat.
- d. Partially exposed joint, evidence of insufficient solder.
- e. Scorched wire insulation or burned connector inserts.
- f. Globules, drips or tails of solder.

If any of the above are present in a finished solder joint, the joint should be taken apart, parts cleaned, and the entire soldering operation repeated, using fresh solder and flux.

SECTION VII

REFERENCE E

EQUIPMENT PERFORMANCE CHARACTERISTICS

The list of equipment which follows represents that currently in use by the Airborne Science Office. It is available on a loan basis for Investigators requiring test equipment during checkout or troubleshooting of their experimental apparatus.

The equipment listings are divided into six categories: amplifiers, meters, oscilloscopes, oscilloscope accessories, power supplies, and signal sources. As new items are added, these lists will be periodically updated to reflect the additions. Questions concerning the characteristics or capabilities of any of the listed units may be addressed to the responsible ASO Electronics Interface Engineer, Mr. James McClenahan, Extension 6484.

Additional equipment is available on a short-term loan basis from the R&QA Office Instrument Control System.

EQUIPMENT PERFORMANCE CHARACTERISTICS

AMPLIFIERS

MFG. & MOD# AMES DECAL#	PRINCETON 113 45086	PRINCETON 113 45103	C-COR 1319FA 39576
Bandwidth	DC to 300 kHz	DC to 300 kHz	2 Hz to 20 MHz
Gain	X 10 to X 10 K	X 10 to X 10 K	0-40 db Var.
Noise	0.3 db	0.3 db	10 μ V RMS
Input Z (DC)	1 G Ω - pF	1 G Ω - 15 pF	1 G Ω - 15 pF
Input Z (AC)	100 M Ω - pF	100 M Ω - 15 pF	75 Ω
Output Z	600 Ω	600 Ω	75 Ω
Output Voltage	10 V P-P Max	10 V P-P Max	8 V P-P Max
Distortion	<.01%	<.01%	2%
Drift	10 μ V 1°C Max	10 μ V 1°C Max	
DC	Yes	Yes	No
Audio	Yes	Yes	Yes
Video	Yes	Yes	Yes
RF	Yes	Yes	Yes
Differential	Yes	Yes	No
Operational	Yes	Yes	No
Power Required	Bat. or 115 V, 60 Hz	Bat. or 115 V 60 Hz	115 V, 50-400 Hz
Power Consumption			
Size	8.6 X 4.1 X 11.3"	8.6 X 4.1 X 11.3"	2 X 4 X 10"
Weight	4 lb.	4 lb.	8 lb.

EQUIPMENT PERFORMANCE CHARACTERISTICS

OSCILLOSCOPE ACCESSORIES (PLUG-INS)

MFG & MOD# AMES DECAL#	TEKTRONIX 1A2 29668	TEKTRONIX 1A2 29669	TEKTRONIX D 22468	
Bandwidth Voltage Range Rise Time Input Z Diff. Input Dual-Trace Used With	DC to 50 MHz* 5 mV to 20 V/CM 7 η S* 1 M Ω - 15 pF No Yes 530, 540, 550 SER. *Limited by Type of Scope Used	DC to 50 MHz* 5 mV to 20 V/CM 7 η S* 1 M Ω - 15 pF No Yes 530, 540, 550 SER.	DC to 2 MHz* 1 mV to 50 V/CM η S* 1 M Ω - 47 pF No No 530 & 540 SER. *DC to 300 kHz @ 1 MV/CM Increasing to DC to 2 MHz @ 50 V/CM	

EQUIPMENT PERFORMANCE CHARACTERISTICS

OSCILLOSCOPES

FIG. AND MOD. NO. AMES DECAL NO.	Tektronix 535A 18219	Tektronix 535A 19598	Tektronix RM502A 36733	Tektronix 211 45210	
Vertical Bandwidth	DC to 14 MHz	DC to 14 MHz	DC to 1 MHz	DC to 500 kHz	
V Voltage Range	See Plug-In Data	See Plug-In Data	100 μ V to 200 V/cm	1 mV to 50 V/Div	
Vertical Input Z	See Plug-In Data	See Plug-In Data	1 M Ω - 47 pF	1 M Ω - 130 pF	
Vertical Rise Time	24 ns	24 ns	-	-	
Dual Trace	See Plug-In Data	See Plug-In Data	Yes	No	
Sweep Time (A)	0.1 μ s to 5 s/cm	0.1 μ s to 5 s/cm	1 μ s to 5 s/cm	5 μ s to 200 ms/Div	
Sweep Time (B)	2 μ s to 1 s/cm	2 μ s to 1 s/cm	-	-	
Delay Time	2 μ s to 10 s	2 μ s to 10 s	None	None	
Sweep Magnifier	X5	X5	X2, X5, X10, X20 \pm 5%	0-X5 Var.	
Horizontal Voltage Range	.2 V/cm to 2 V/cm	.2 V/cm to 2 V/cm	0.1 V to 2 V/cm	1 V and 10 V/Div	
Horizontal Input Z	1 M Ω - 350 kHz	1 M Ω - 350 kHz	1 M Ω - 70 pF	.5 M Ω - 30 pF	
Horizontal Band Width	DC to 350 kHz	DC to 350 kHz	DC to 100 kHz	DC to 75 kHz	
CRT Area	6 X 10 cm	6 X 10 cm	8 X 10 cm	6 X 10 Div	
CRT Phosphor	P2	P2	P2	P31	
Power Required	115 V rms, 50-60 Hz	115 V rms, 50-60 Hz	115 V rms, 60 Hz	Bat. or 115 V 60 Hz	
Power Consumption	550 W	550 W	290 W	2 W	
Size	17 X 13 X 24 in.	17 X 13 X 24 in.	12 $\frac{1}{4}$ X 19 X 22 in.	3 X 5.3 X 8.9 in.	
Weight	61 $\frac{1}{4}$ lbs.	61 $\frac{1}{4}$ lbs.	58 lbs.	3 lbs.	
Portable	No	No	No	Yes	

EQUIPMENT PERFORMANCE CHARACTERISTICS

METERS

MFG. AND MOD. NO. AMES DECAL NO.	Honeywell VF 100 45018	Fluke 8000A 45172/45173	Hewlett-Packard 410B 21077	Simpson 260 40969/40997	Hewlett-Packard 2401C 31591
Read-Out	3 Digits	3½ Digits	Meter, 4"	Meter, 4½"	6 Digits
Voltage Range	1,000 Vdc	±199.9 mV/1199 V	1 V to 300 V	2.5 to 5000 V	0.1 V to 1000 V
DC Volts Acc.	0.2% + 1 Digit	0.1% + 1 Digit	±3% of FS	±2% of FS	±.01% + 1 Digit
AC Volts Acc.	-	0.7% + 2 Digits	±3% of FS	±3% of FS	-
Current Range	-	±199.9 µA/1999 mA	-	50 µA to 10 A	-
DC Current Acc.	-	0.3% + 1 Digit	-	2% of FS	-
AC Current Acc.	-	1% + 2 Digits	-	-	-
Input Z	1000 MΩ	10 MΩ	10 MΩ AC/122 MΩ DC	20 KΩ/Volt	10 MΩ
Freq. Response	-	45 Hz to 20 kHz	20 Hz to 7000 MHz	20 Hz to 200 kHz	-
Response Time	1 sec.	½ s DC, 3 s AC	-	-	.01 to 1 s
Resistance Range	-	199.9Ω/19.99 MΩ	.2Ω to 500 MΩ	R X 1 to R X 10 KΩ	-
Resistance Acc.	-	0.2% + 1 Digit	±5% of MS	2° of ARC	-
Frequency Meas.	-	-	-	-	5 Hz to 300 kHz
Period Meas.	-	-	-	-	5 Hz to 10 kHz
Power Required	115 V, 50,60,400 Hz	115 V, 50-400 Hz	115/230 V, 50-1 kHz	Batt	115/230 V, 50-60 Hz
Power Consumption	10 V A	2 W	40 W	-	150 W
Size	-	8½ X 2½ X 10	7-3/8 X 11½ X 8-3/4	5¼ X 7 X 3¼	19 X 7 X 18-3/8
Weight	-	2-3/4 lbs.	12 lbs.	3 lbs.	48 lbs.
BCD Output	Yes	Option	-	-	Yes

EQUIPMENT PERFORMANCE CHARACTERISTICS

POWER SUPPLIES

MFG. AND MOD. NO. AMES DECAL NO. TYPE	Unitron PS61-33D 44930 Freq. Converter	Unitron PS61-33D 45376 Freq. Converter	Kepco 121217-1 40995/40996 DC	Lambda LK36 (5) 45482-6 DC	
Input Voltage	115 V or 200 V	115 V or 200 V	115 V	115 V to 132 V	
Input Configuration	3 ϕ Delta or Y	3 ϕ Delta or Y	Single ϕ	Single ϕ	
Input Frequency	360 Hz to 440 Hz	360 Hz to 440 Hz	60 Hz	47 Hz to 63 Hz	
Output Voltage	115 V \pm 3 V	115 V \pm 3 V	0-2 V DC	0-36 V DC	
Regulation	-	-	-	0.15% = 1 mV	
Ripple	-	-	-	500 μ V	
Output Frequency	60 Hz \pm 0.6 Hz	60 Hz \pm 0.6 Hz	60 Hz \pm 0.6 Hz	60 Hz \pm 0.6 Hz	
Output Configuration	Single ϕ	Single ϕ	Single ϕ	Single ϕ	
Output Power	8000 V A	8000 V A	0-1 A	48 A	
Size	12 X 20 X 23 $\frac{1}{2}$	12 X 20 X 23 $\frac{1}{2}$	12 X 20 X 23	7 X 19 X 16 $\frac{1}{2}$	
Weight	250 lbs.	250 lbs.	250 lbs.	135 lbs.	

EQUIPMENT PERFORMANCE CHARACTERISTICS

SIGNAL SOURCES

MFG. AND MOD. NO.	Wavetek 144	Hewlett-Packard 200CD	Hewlett-Packard 202A	Systrom-Donner 401	Tektronix 180A
AMES DECAL NO.	44999	19274	21082	45043/45044	21017
Frequency Range	.0005 Hz to 10 MHz	5 Hz to 600 kHz	.008 Hz to 1.2 kHz	.02 Hz to 2 MHz	.1 μ s to 10 ms
Frequency Response	<2 dB to 10 MHz	± 1 dB	± 2 dB	$\pm 1\%$ to 200 kHz	-
Dial Accuracy	$\pm 2\%$	$\pm 2\%$	$\pm 2\%$	$\pm 2\%$	-
Output Waveforms	5	1	3	3	2
(1) Sinusoidal	Yes	Yes	Yes	Yes	Yes .1 μ s
(2) Square	Yes	No	Yes	Yes	No
(3) Triangular	Yes	No	Yes	Yes	No
(4) Pulse	Positive & Negative	No	No	No	Time-Marks
Distortion	<1%	<.5%	1%/2% on X100	.5% to 200 kHz	-
Output Voltage	30 V P-P, Open Ckt.	10 V into 600 Ω	30 V P-P/4 k Ω	20 V P-P, Open Ckt.	1 V P
Output Z	50	600	40	50 or 600	80
Freq. Stability	$\pm .25\%$ for 24 Hrs.	-	1%	.05%	.005%
Rise/Fall Time	<20 ns	-	-	<40 ns	.1 μ s to .8 μ s
Sync. Output	2 V P-P/50 Ω	None	10 V P Negative	None	-
Attenuator	$\pm .25$ dB/10 dB	Bridged "T"	Bridged "T"	Pot	-
Sweep Time	10 μ s to 100 s	None	None	External	-
Sweep Width	1000 to 1	None	None	1000:1	-
Power Required	115/225 V, 50-400 Hz	115/230 V, 50-1 kHz	115/230 V, 50-1 kHz	-	115 V, 50-800 Hz
Power Consumption	<30 W	90 W	150 W	-	100 W
Size	8 $\frac{1}{2}$ X 5 $\frac{1}{4}$ X 11 $\frac{1}{2}$	7-3/8 X 11 $\frac{1}{2}$ X 14-3/8	20-3/4 X 12-3/4 X 15-3/8	-	18 X 6-7/8 X 10 $\frac{1}{2}$
Weight	10 lbs.	22 lbs.	42 lbs.	-	-
Modulation	FM 1000:1	None	None	FM 1000:1	-